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OF

The Royal Society

OF

Western Australia.

Vol. XIX.

1932-33.

The Authors of Papers are alone responsible for the statements
and
the opinions expressed therein.

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1934.

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THE ROYAL SOCIETY OF WESTERN AUSTRALIA.

OFFICERS AND COUNCIL, 1932–33.

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T. H. Wilson.
H. Womersley, F.E.S.

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Volume XIX.

ANNUAL REPORT OF THE COUNCIL FOR YEAR ENDING 30th JUNE, 1933.

Ladies and Gentlemen,

Your Council begs to submit the following report for the year ended 30th June, 1933.

There are 213 members on the roll, of whom nine are honorary members, seven corresponding members, 107 ordinary members, 66 associate members, and 24 student members. During the year nine ordinary members and nine associate members have been elected, while two ordinary members have resigned. The names of six members have been removed in accordance with Rule 13. Mr. D. L. Serventy was elected a corresponding member for the period of his tenure of the 1851 Scholarship abroad.

We regret to report the loss, by death, of two members of the Society —Mr. A. Montgomery, a foundation member and past president of the Society, and Mr. H. E. Pearson, an associate member of the Society.

Council.

Ten ordinary meetings and one special meeting of the Council were held during the year.

Mr. H. Womersley resigned from the Council on account of leaving the State, and Dr. E. S. Simpson resigned on account of ill-health.

Dr. H. W. Bennetts and Mr. G. W. R. Meadly were elected by the Council to fill the vacancies.

Finance.

The grant received from the Treasury during the year was at the rate of £80 per annum, and the Council wishes to express its thanks to the Government for the subsidy. Without the aid of the Government grant the publication of papers in the Journal would have to be even more seriously curtailed than at present.

A matter giving your Council considerable concern is the cost of printing papers coming forward from student members of the Society who are also research workers at the University. It is the aim of the Council to encourage the publication of papers by students where they are recommended by the appropriate University Department. It is, however, necessary that the publication rights of senior members should be jeopardised by this consideration. The Council is in communication with the University authorities in connection with the matter, and it is hoped that an arrangement satisfactory both to the University and the Council will eventuate.

Publications.

Volume 18, containing the proceedings and transactions of the Society for 1931-32, has been completed, and will shortly be issued to members and distributed in accordance with the exchange list. Volume 19, containing proceedings for 1932-33, is well in hand. All papers contributed to the Society by full members have been finalised. It is hoped that the volume

will be completed and issued to members early in the coming session. Mr. B. L. Southern has again carried out the duties of editor, and the Council desires to express its appreciation of his work.

Conference of Royal Societies.

During the Sydney meeting of the Australian and New Zealand Association for the Advancement of Science, a conference of Royal Societies of Australia was held. At this conference Mr. H. Bowley, F.A.C.I., and Miss L. Hosking, B.A., represented this Society. It was decided that no amalgamation of Royal Societies of Australia is desirable at present, but it was recommended that a loose federation should be formed through the appointment of a representative of each Royal Society and of the Linnean Society, New South Wales, to the Council of the Australian National Research Council.

Hancock Memorial Window.

This Society was invited to subscribe to the Hancock Memorial Window Fund. The window is being erected within the University, Crawley, in memory of Dr. Hancock, who was the first Gold Medallist of the Royal Society. An amount of £5 5s. was subscribed, £2 5s. being made up of individual subscriptions, and £3 representing a donation from the Medal Fund.

Royal Society's Gold Medal, 1932-33.

The Gold Medal to be awarded in 1932-33, in accordance with the rules, has been awarded to Mr. W. M. Carne, F.L.S., a corresponding member and past President of the Society, for his work in connection with bitter pit and allied diseases affecting apples in storage and transport.

Excursions.

During the year six excursions were held.

Flora and Fauna Committee.

The Flora and Fauna Committee, which is represented on the State Advisory Committee appointed by the Hon. the Minister for Customs, by its convener, has not met during the year, although the interests of our fauna have been carefully watched.

ROYAL SOCIETY OF WESTERN AUSTRALIA.

Hon. Treasurer's Statement of Receipts and Expenditure for the year ending June 30th, 1933.

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance in Bank 1st July, 1932—						
Medal Fund	23	0	0			
General Fund	36	2	5			
				59	2	5
Subscriptions				96	15	3
Government Grants, July, 1932, to June, 1933				80	0	0
Authors' Reprints and Donations				13	4	2
Excursion Receipts				9	9	3
Collection for Dr. Hancock Memorial Window at University ...				2	5	0
Interest on Current Account				2	12	1
				£263	8	2

EXPENDITURE.

	£	s.	d.	£	s.	d.
Petty Cash				18	15	8
Typing				5	17	6
Donation to Dr. Hancock Memorial Window Fund				5	5	0
Stationery				1	8	0
Expenses for Annual Meeting, 1932				4	11	7
Post Office Box Rent, 1-1-33 to 31-12-33				3	0	0
Honorarium to Editor (Vol. XVIII).				15	15	0
Museum Trustees—Fees and attendance, 1st July, 1932, to 30th June, 1933				19	1	0
Catering for December, 1932, meeting				1	17	6
Excursion Expenses				8	10	0
Government Printer :—						
1. Printing 8 pages and cover, Paper XI., and Presidential Address, Vol. XVIII.	41	5	2			
2. Printing Papers I–V., Vol. XIX. (complete)	23	9	11			
3. Printing Papers VI.–VIII., Vol. XIX. (as yet incomplete)	17	7	4			
4. Printing Programme and Invitation Cards (General and Section Meetings) July, 1932, to June, 1933	4	10	0			
5. Lantern Slides	0	17	0			
6. Miscellaneous Printing	3	9	10			
				90	19	3
Balance in Bank, June 30th, 1933 :—						
Medal Fund	20	0	0			
General Fund	68	7	8			
				88	7	8
				£263	8	2

In addition to the above there is an amount of £132 6s. (Endowment Fund) on fixed deposit at 3½ per cent. interest for two years, maturing 12th June, 1934, at the Commonwealth Bank, Perth.

A sum of £24 10s. has been spent since the close of the books on 30th June, 1933, for the Royal Society's Gold Medal recently awarded to Mr. W. M. Carne. The Editorial Secretary stimates that a further £10 (approximately) will be required to finish the printing of papers 6, 7 and 8 of Vol. 19. The printing of further papers in hand but not yet commenced will cost approximately £90.

Examined and found correct,—

R. E. GATHERER
G. SPENCER COMPTON } Hon. Auditors.

8th July, 1933.

H. A. PITTMAN,
Hon. Treasurer.

ABSTRACT OF PROCEEDINGS, 1932-33.

12TH JULY, 1932—

Annual General Meeting held at Karrakatta Club. Presidential Address: "The Kino of Eucalyptus Calophylla." Mr. L. W. Phillips.

9TH AUGUST, 1932—

Lecturette—Prof. E. de C. Clarke communicated a paper by Miss D. Carroll: "Mineralogy of Some Western Australian Soils."

Papers—"The Origin of the Liquid Appearing from the Soft Spines and Tail of the Lizard *Diplodactylus spinigerus*" and "Sarcosposidia," Mr. G. Bourne.

13TH SEPTEMBER, 1932—

Lecture—"Science Applied to Agriculture in Western Australia," Mr. G. L. Sutton.

Paper—"Specific Naming of Aulosteges from Western Australia"; "Fossils from the Wooramel District," Miss L. Hosking.

Paper—"Minyulite, a New Phosphate Mineral from Dandaragan, Western Australia," Dr. E. S. Simpson and Mr. C. R. Le Mesurier.

11TH OCTOBER, 1932—

Paper—"Distribution of the Smaller Marsupials in Western Australia," Mr. L. Glauert.

Paper—"Devonian Rocks in the Kimberley Division," Miss L. Hosking.

Lectures—"The Suggested Improvement of Cattle in Tropical Australia by Crossing with Zebus" and "Some Improvements in Wheat Breeding Technique," Mr. C. B. Palmer.

15TH NOVEMBER, 1932—

Paper—"The Geology and Physiography of the Jimperding Area," Mr. R. T. Prider.

Lecture—"Science in the Mining Industry of Western Australia," Mr. R. C. Wilson.

13TH DECEMBER, 1932—

Exhibit Evening.

14TH MARCH, 1933—

Paper—"Contribution to Flora of Western Australia, No. 8," Mr. C. A. Gardner.

Lecture—"Some Aspects of Survey Exploration in the Interior of North-Western Australia," Mr. A. W. Canning.

11TH APRIL, 1933—

Lecture—"Some Problems in Animal Pathology in Western Australia," Dr. H. W. Bennetts.

Lecture—"Some Problems in Plant Pathology in Western Australia," Mr. H. A. Pittman.

9TH MAY, 1933—

Paper—"Coastal Limestones," Mr. R. W. Fletcher.

Lecture—"Sylvicultural Problems in Western Australia," Mr. S. L. Kessell.

13TH JUNE, 1933—

Paper—"The Brachyura of South-Western Australia," by Dr. H. Balss, communicated by Mr. E. W. Bennett.

Lecture—"Entomological Problems—Past and Present," Mr. L. J. Newman.

BIOLOGICAL SECTION.

Abstract of Proceedings.

19TH JULY, 1932—
Lecture—" Marine Collecting in Western Australia," Dr. Lyman Clark.

16TH AUGUST, 1932—
Lecture—" Distribution of the Smaller Marsupials in Western Australia," Mr. L. Glauert.

18TH OCTOBER, 1932—
Lecture—" Biological Control," Mr. B. A. O'Connor.

20TH NOVEMBER, 1932—
Lecture—" The Vegetation of Western Australia," Mr. C. A. Gardner.

21ST MARCH, 1933—
Discussion—" Mimicry and Protective Coloration in Animals."

4TH APRIL, 1933—
Discussion—" What is a Xerophyte."

16TH MAY, 1933—
Discussion—" Balance of Nature."

20TH JUNE, 1933—
Lecture—" The Higher Crustacea of Western Australia," Mr. E. W. Bennett.

W. M. Carne, F.L.S.
Gold Medallist, 1932-33.

Mr. Carne was educated at the Sydney High School and the Sydney Technical College, and from 1906 to 1911 was Assistant and Acting Lecturer in Plant Pathology, Botany, and Entomology at the Hawkesbury Agricultural College. In 1912-13 he served as a cadet in the Department

of Agriculture, University of Sydney. In 1914-15 he was Assistant Agrostologist, Department of Agriculture, New South Wales. His career was interrupted by five years service with the A.I.F. Enlisting as a private, he rose to the rank of Lieutenant. He was mentioned in despatches, and awarded the Serbian Silver Medal. In 1920-22 he acted as Lecturer in Botany at the Hawkesbury Agricultural College, and from 1923-28 was Economic Botanist and Plant Pathologist to the Department of Agriculture, Western Australia. In 1929 he was appointed Senior Plant Pathologist, Division of Plant Industry, Council for Scientific and Industrial Research. He is a corresponding member of the Royal Society of Western Australia, and a member of the following other learned Societies:—Royal Society, Tasmania; Linnean Society, London; Linnean Society, New South Wales; and British Mycological Society.

Mr. Carne is responsible for the following publications:—

1912 Effects of Formalin on Germination of Wheat.—Bureau of Microbiology, N.S.W. Annual Report.

1924 Occurrence of Certain Natural Crossbreds in Oats and Barley. With E. J. Limbourn.—Roy. Soc. W.A.

1925 Preliminary Census of Plant Diseases of S.W. Aust.—Roy. Soc. W.A.
A Brown Rot of Citrus in Australia—Roy. Soc. W.A.

1926 Earcockle and a Bacterial Disease of Wheat. —Jnl. Agric. W.A.

1927 Grey Speck Disease of Wheat and Oats—Jnl. Agric. W.A.
Additions to Plant Diseases of S.W. Aust.—Roy. Soc. W.A.

1928 Outline of History of Phytopathology.—Roy. Soc. W.A.

1929 Bitter Pit of Apples (with Pittman and Elliott). C.S.I.R. Bull. 41.
Some Problems of the Aust. Apple Export Industry.—Roy Soc. W.A.

1930 Wastage of Non-parasitic origin in Stored Apples.—C.S.I.R. Jnl.

1931 Present Position of Bitter Pit Problem in Australia.—Proc. Imp. Hort. Conference 1930.
Heavy and Light Cropping of Apples in Alternate Years.—C.S.I.R. Jnl.

1932 Export of Aust. Apples.—C.S.I.R. Jnl.

Some 30 articles, mainly popular, on plant diseases in Jnl. Agric. W.A. and Jnl. C.S.I.R. About 45 articles on pasture plants, weeds, poison plants, seeds, etc., in Jnl. Agric. W.A. Approximately 20 papers and articles on ecological and miscellaneous botanical subjects in Proc. Linnean Soc. N.S.W., Jnl. Naturalists Soc. N.S.W., Agric. Gazette, N.S.W. etc. written before 1923.

The principal research on which this recommendation is based is that on the Bitter Pit of Apples, in which investigation Mr. Carne has shown great tenacity of purpose, breadth of knowledge, and scientific skill. This investigation was conducted under the auspices of the Council for Scientific and Industrial Research, but carried out by Mr. Carne within the Department of Agriculture in Western Australia. He had associated with him Messrs. H. A. Pittman and H. G. Elliott, both of whom are on the staff of the Department. Dr. Dickson in referring to this investigation stated that the work is fundamentally sound, and that he has no fear of criticism of it; in fact, corroboration of the conclusions is gradually forthcoming. Mr. Carne may be described as a man "faithful to science, and whose work in most difficult problems of nearly half a century's incidence will stand the test of time."

JOURNAL OF THE ROYAL SOCIETY OF WESTERN AUSTRALIA.
Vol. XIX., 1932-1933.

PLANT RESPONSE TO THE DRY PHASES OF THE CLIMATE OF SOUTH-WEST WESTERN AUSTRALIA.

PRESIDENTIAL ADDRESS

By

W. E. Shelton, B.Sc.

Delivered 11*th July* 1933; *Published* 26*th April*, 1934.

To most members of a community such as ours the presence of the native vegetation is not a matter of great concern except perhaps when it is deemed necessary to remove it to make way for the handiwork of man. At other times we may be grateful for the shade which tempers the heat of a summer day or for the stirring of admiration in response to its beauty, particularly when springtime brings its riot of blossom. But these and other exceptions have not freed me from a considerable diffidence in electing to speak at length about our native plants.

As many who are present this evening have but little interest in matters botanical, first let me attempt to quicken that interest by emphasising the value of the vegetation of a region.

Firstly, plants are responsible for the manufacture of the world's supply of food. Up to within a little more than one hundred years ago, the native plants of this land prepared all the foods needed to build up and nourish the bodies of the plants and animals, including man, which until that time had existed in the region. Unimportant exceptions are such as the flesh of migratory birds or visiting fish or whales. Almost each scrap of food consumed in those days could be traced to its origin in some green plant of the area which by the process of photosynthesis had caused inorganic substances to combine to become foods of value to plants and animals

Fig. 1.—Locality Map, indicating positions of places mentioned in address. See also Fig. 4.

Fig. 2.—Western Australian pastoral country rendered barren by wind removal of soil following overstocking with sheep.

Photo., C. A. Gardner.

Secondly, plants play an almost equally important role in maintaining the oxygen to carbon-dioxide ratio in the atmosphere we breathe. Various processes of oxidation such as combustion of carbon and its compounds, respiration and decay cause atmospheric oxygen to be replaced by carbon dioxide. This exchange is reversed during the photosynthetic activities of plants.

A third fact is important in a land such as ours. In regions of seasonal or irregular droughts a cloak of vegetation, by retarding the run-off of rain, will lessen the length of the dry season. There will be an increased air humidity due to the transpiration of vast quantities of water vapour, and this, in the opinion of some, may increase the precipitation of dew and prolong the rains of the wet season.

Fourthly, temperatures are rendered more equable. Daily maxima are appreciably lowered in summer by shading of the ground, by cooling due to evaporation from plant surfaces and by absorption of radiant heat by the water vapour in the air. There is also a tendency to prevent extremely low minima at night.

As a fifth fact, it must be remembered that a vegetation cloak minimises the removal of soil by running water and wind. Forest destruction has led to almost total loss of fertility in the highlands of China and in Palestine. The latter country affords an especially interesting example, partly because it has a climate resembling that of our own portion of Australia and also in that it is slowly recovering from its occupation by the pastoral Turk who effectively discouraged agricultural industry. During that period of repression, forests, plantations, gardens and much of the soil gave place to barren rock and subsoil with consequent increase of aridity and extremes of temperature. In parts of our own State similar results have followed the thoughtlessness of settlers. The soil of pastoral areas has been removed by wind following the destruction of plants by overstocking with sheep (see fig. 2) and many a wheat farmer has lamented the loss of his best soil as, in wind-borne clouds, it disappeared from his well-worked fallow.

The sixth value is an obvious one. Plants supply many of our requirements and in addition to foods and beverages, there may be mentioned timber, fibres, fuel, cellulose, drugs, dyes, oils. A forest is a greater asset than the richest of gold-mines.

A seventh fact also calls for little comment. Our plants, individually and collectively, have an undoubted aesthetic appeal and even the most materially-minded of us at times must respond to a stirring of the senses as age-old as our race itself.

The foregoing remarks have been made in the hope that those of you who in the past have thought but little about plants have now in mind that

the vegetable world is essential for our existence and in addition contributes in no small measure to our comfort of body and mind. I trust that now you will be sufficiently interested to follow me in a consideration of those particular plants which grow in the South-West corner of our State.

Fig. 3.—Morrell (*Eucalyptus longicornis*) showing a tree-top pattern characteristic of the timber of the Wheat Belt and Eastern Goldfields. Note especially the distant trees.

From a Primer of Forestry, S. L. Kessell.

To anyone who has not left our shores our plants may not exhibit any peculiarities. Even casual observers from abroad merely become conscious that here we have an assemblage of trees, shrubs and herbs and similar vegetation forms have been encountered in many other parts if the world. The prevalence of sombre hues, the frequent meagreness of shade and the spikiness and harsh texture of many a leaf have for them no especial significance. But a consideration of our climatic conditions leads to a different conclusion. We enjoy a typically Mediterranean climate. Our winters are mild and rainy though clear sunny days are numerous. The summers are hot with almost complete absence of cloud and rain. It would be difficult to find a land with more sunshine. But these statements are too general to be of much value in forming an estimate of the climatic conditions experienced by our plants. To convey exact ideas, from records kindly made available by the W.A. Branch of the Commonwealth Meteorological Bureau, I have prepared a series of diagrams to indicate the water resources available over the South-West of this State.

Figure 4 shows the course of the annual isohyets and was copied from a map utilising rainfall records received up to the end of 1931. An interesting feature is the irregularity of the rainfall zones in the east of the area, particularly in the case of the 15—20 inch belt. Another is the close relationship between the 20 inch isohyet and the eastern boundary of the jarrah* region. The effect of topography on rainfall is made apparent by the manner in which the 40 inch isohyet is caused to deviate 150 miles northward by the plateau scarp lying some twenty-five miles inland from the west coast. But in some respects the annual isohyets are misleading and the seasonal nature of our rainfall calls for separate isohyet maps for summer and winter. Unfortunately these are not available, so figures 5 and 6 have been prepared and from them it may be inferred that the irregularities of the eastern areas are due in great part to the sporadic and uncertain summer rains. Figure 5 shows the average monthly rainfall for a number of representative towns of the area. The number following the name of the town indicates in years the period over which averages have been taken, the last year in each case being 1932. The number below the name of the town is the average annual rainfall in points for the same period.

Figure 6 has been designed to show the reliability of winter rains (June and July rainfall) and the irregular and uncertain nature of the summer precipitation (rainfall for December and the following January).

In compiling this table it was surprising to note the frequent summer aridity of localities generally considered to be well watered. At Pemberton, for instance, in karri† country about twenty miles from the extreme south of the State, twice in the last six years has the total rainfall for five consecutive summer months amounted to but little more than one and a half inches. In the summer of 1927-28, the total rainfall from November to March inclusive was 169 points contrasted with 3,694 points in the following five months. In 1931-1932, 167 points were registered during the same five summer months and in January, February and March, 1930, the fall was only 19 points contrasted with 2,531 points in June, July and August.

* Jarrah = *Eucalyptus marginata*. † Karri = *Eucalyptus diversicolor*.

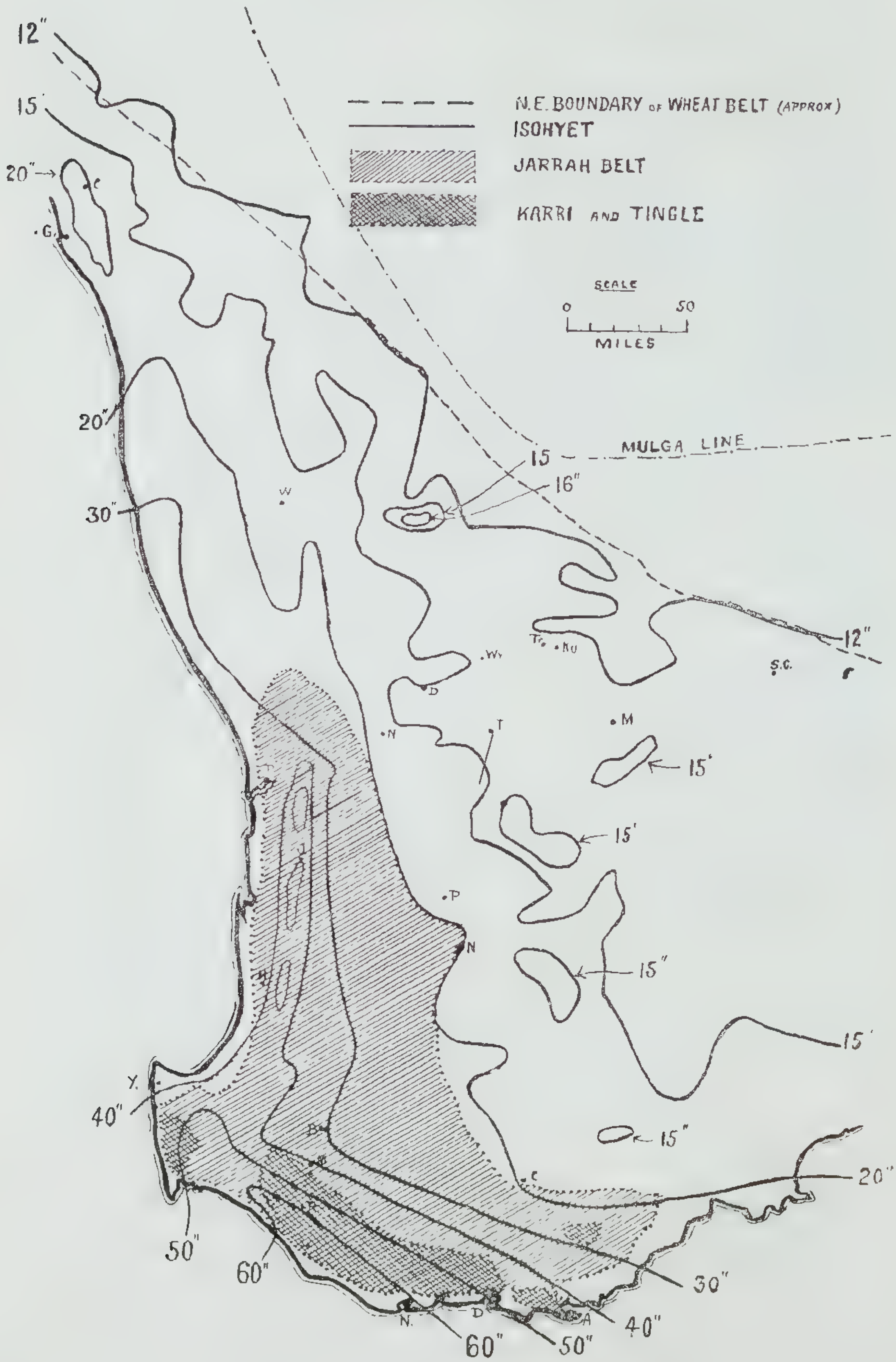

Fig. 4.—Isohyet map based on statistics to the end of 1931. Wheat, jarrah and karri belts are shown. Tingle occurs only in the extreme south of the main karri belt.

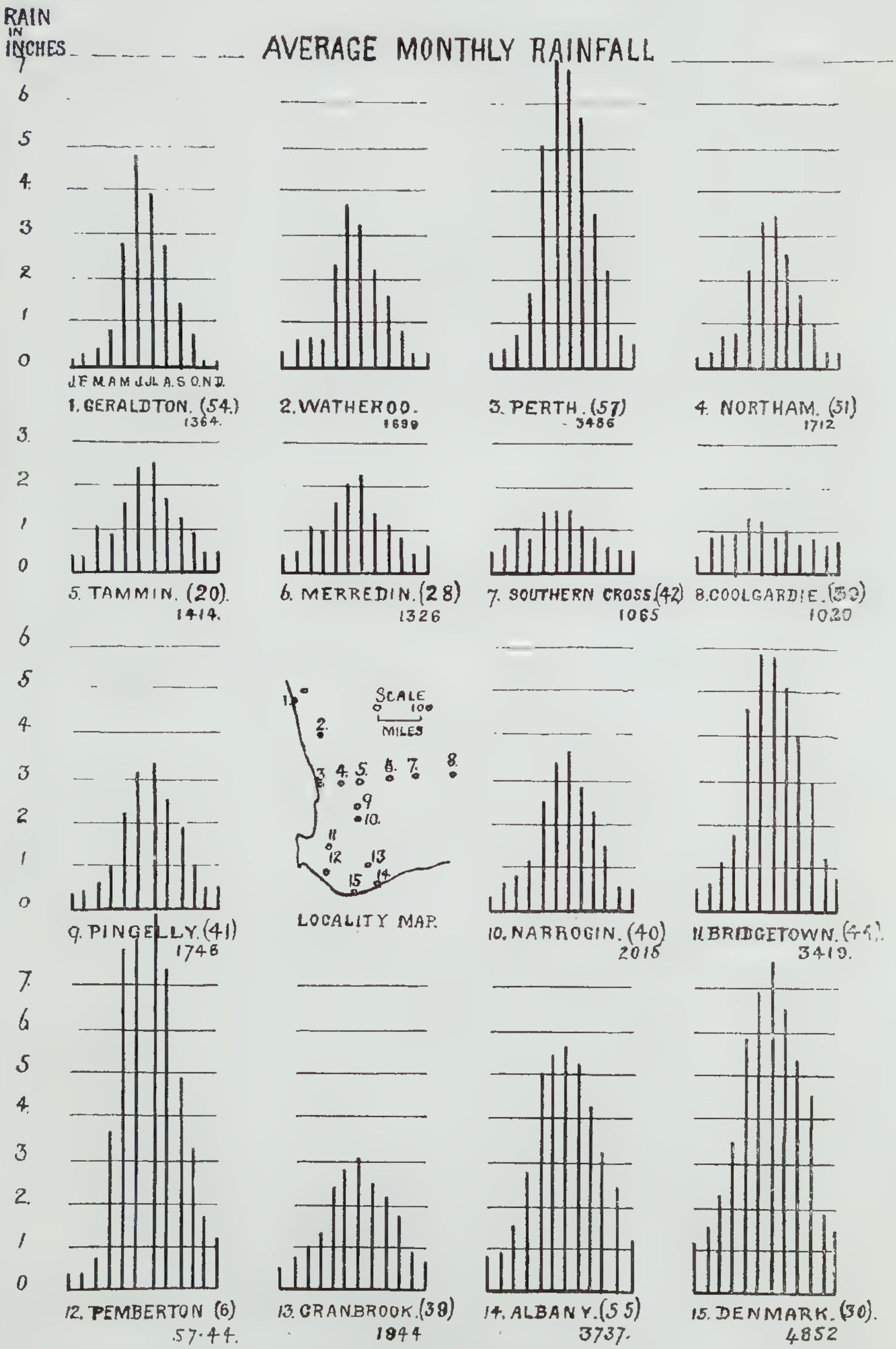

Fig. 5.—Graphical representation of the average monthly rainfall of towns of the South-West Division of W.A. Figures in brackets after name of town indicate number of years (including 1932) over which statistics have been averaged. The number below the town name is the average rainfall in points for the same period.

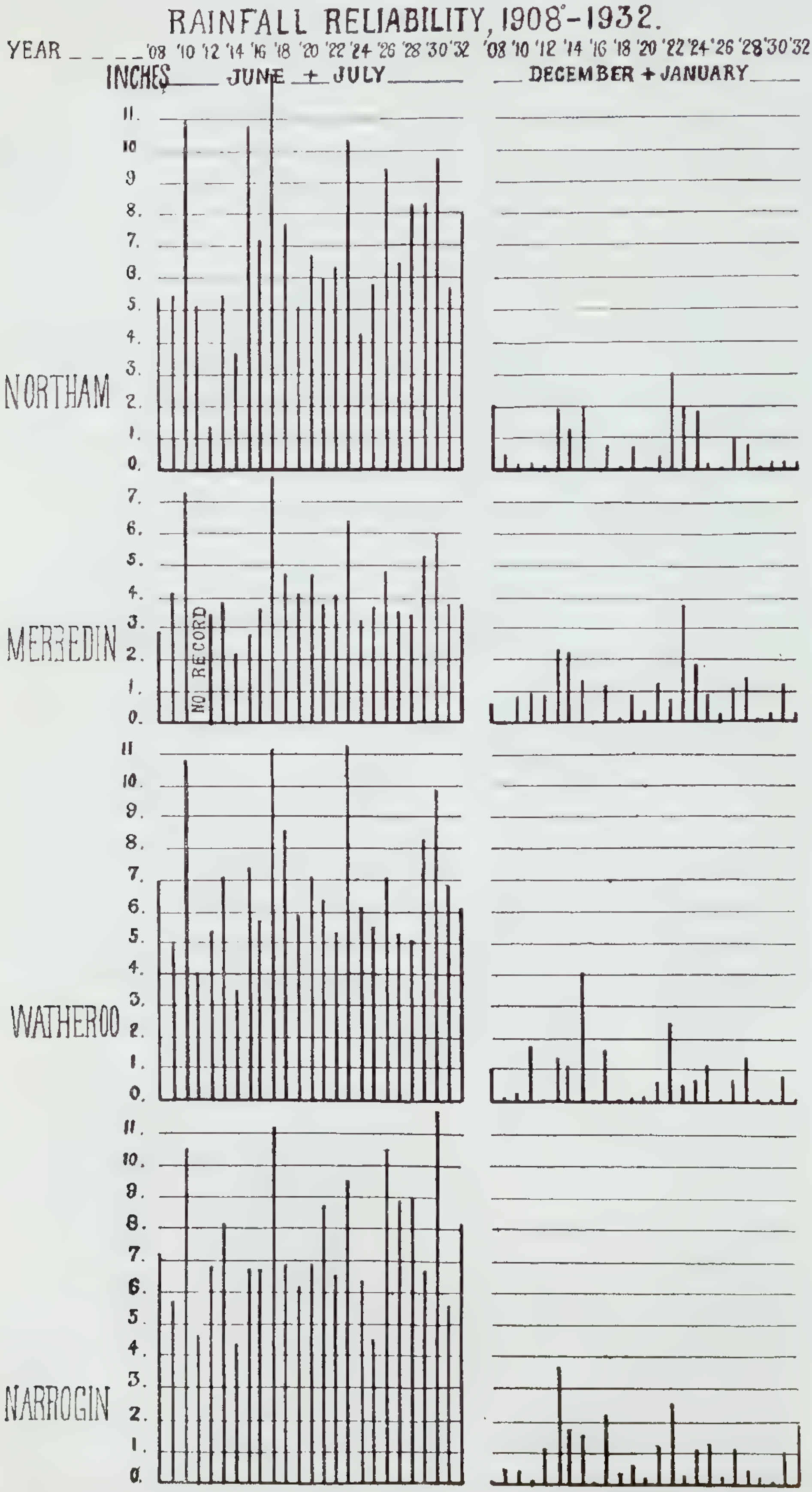

Fig. 6.—Graphical illustration of the reliability and sufficiency of winter rains (June and July) contrasted with the irregularity and deficiency of the summer rainfall (December and the following January) for twenty-five years.

Fig. 7 gives available statistics concerning evaporation. If comparisons between stations are made it must be remembered that the figures for Coolgardie were obtained by means of a tank somewhat sheltered from wind.

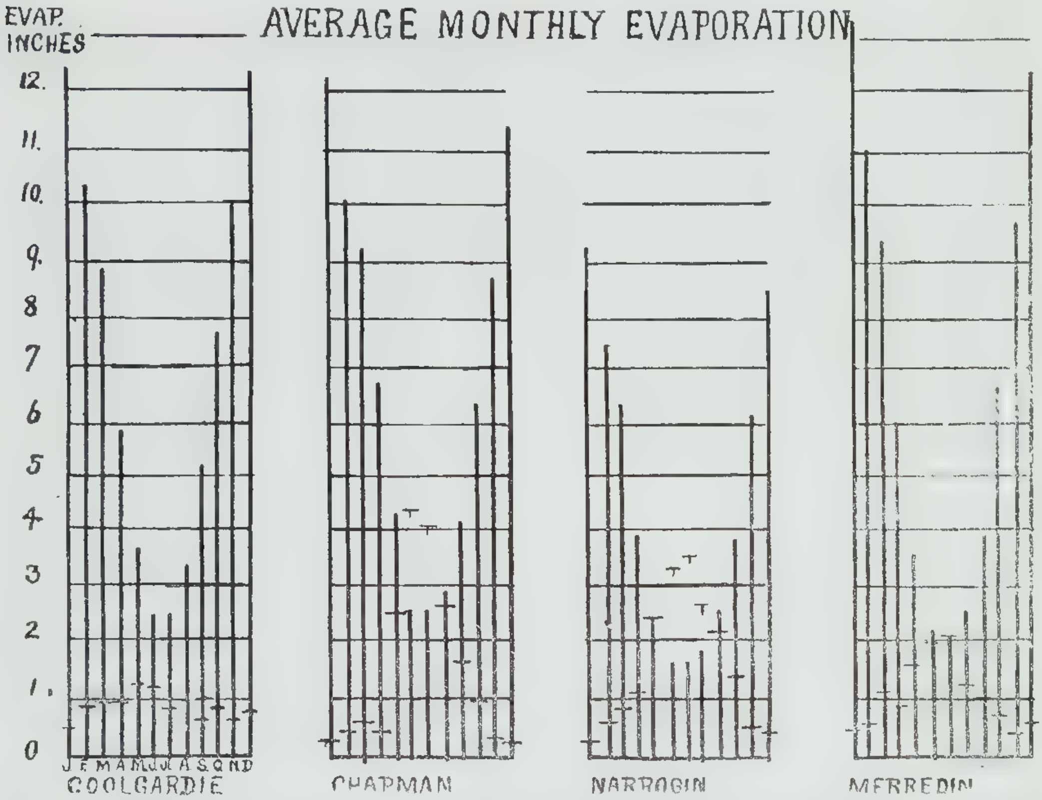

Fig. 7.—Evaporation and rainfall contrasts. The tall columns indicate average monthly evaporation in inches, and the short horizontal lines intersecting them the average monthly rainfall.

[Figures 4, 5, 6 and 7 have been constructed from statistics made available by the W.A. Branch of the Commonwealth Meteorological Bureau.]

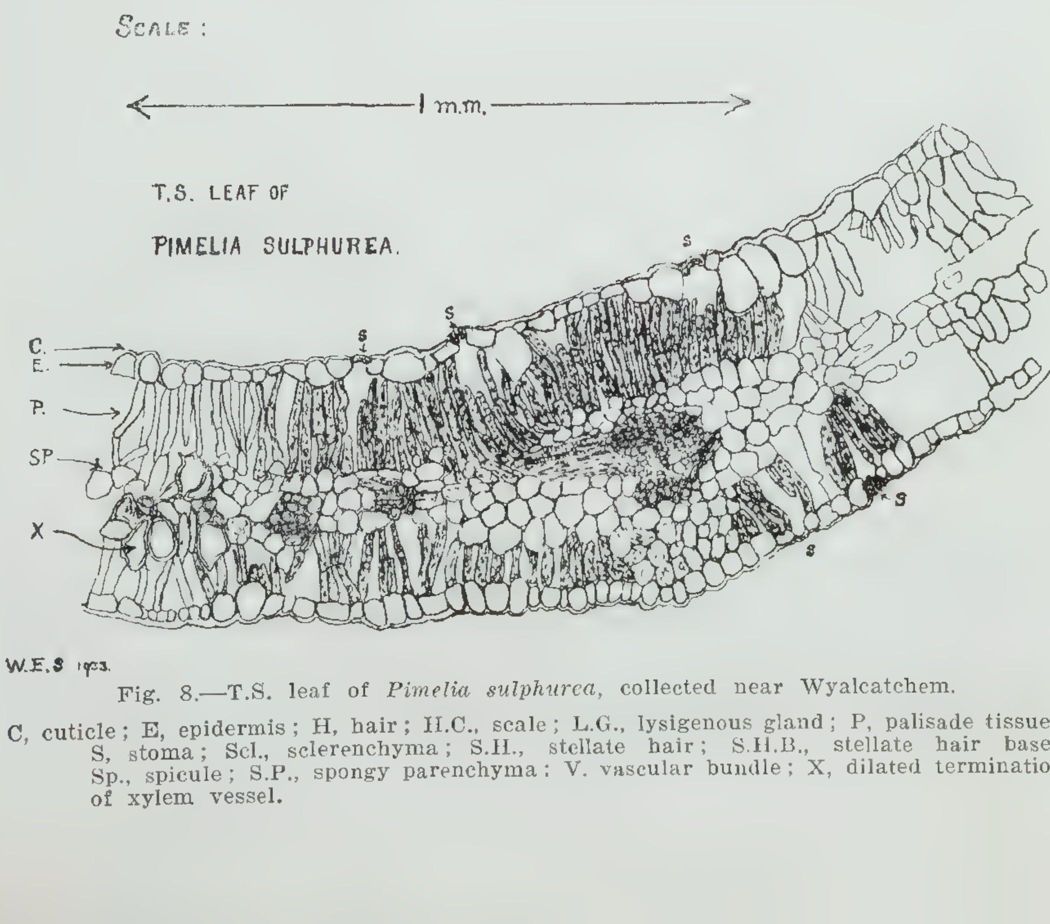

Fig. 8.—T.S. leaf of *Pimelia sulphurea,* collected near Wyalcatchem.

C, cuticle; E, epidermis; H, hair; H.C., scale; L.G., lysigenous gland; P, palisade tissue; S, stoma; Scl., sclerenchyma; S.H., stellate hair; S.H.B., stellate hair base; Sp., spicule; S.P., spongy parenchyma; V. vascular bundle; X, dilated termination of xylem vessel.

The instrument in each case consisted of an open tank provided with a water jacket. In order to make this diagram more valuable, the average monthly rainfalls have been indicated by short horizontal lines crossing the columns representing evaporation.

From the statistics available it is evident that during the winter months rainfall is abundant in the whole of the South-West. Even stations distant from the coast such as Southern Cross and Coolgardie receive sufficient reliable winter rain to enable plants to thrive in that season. It would be difficult to find a more reliable winter rainfall. Even so, it must be noted that at Coolgardie and Merredin, the average monthly precipitation never exceeds evaporation and at Chapman and Narrogin it does so only during two and three months at mid-winter, whilst towards the end of that season it is very greatly exceeded by evaporation. But the springtime brings a double change. There is a strikingly rapid shrinkage in the rainfall and a tremendous increase in the rate of evaporation. The prevailing wind, indicated by a distinct leaning of trees in many parts of the wheat belt, is the south-east trade, and under its drying influence evaporation becomes twenty-five to fifty times as great as the rainfall. Even as early as September the soil and air of the more inland portions of the area are becoming distinctly drier and in wetter regions such as the Pemberton district of the Karri belt, on the drier slopes and porous localities, soil water is scarce long before April brings the onset of the following winter rains. Another aspect of the scanty summer rainfall is its unreliability. Much of it occurs during thunderstorms, and these are localised disturbances, producing rain and hail over limited areas. In fact one farm may be deluged whilst a neighbouring one does not receive a drop.

More widespread rains may accompany the formation of low pressure troughs connecting equatorial and antarctic cyclonic systems, but such meteorological conditions are not frequent. On the contrary, it is quite possible for large tracts of country to receive no rainfall during four or five of the summer months.

Precipitation other than rain may be of importance. Although no figures are available concerning the quantity of dew deposited at any stations, records show that dewy nights are numerous. At Perth a quarter of the nights are dewy. Although the inland atmosphere is drier, night temperatures are lower; so it is not surprising that heavy dew is also experienced in localities remote from the coast. Snow is negligible for although scanty falls have been recorded, they occur at intervals of years.

We are now able to turn to our plants with a new interest. The majority of the perennials must be capable of existing for at least four or five consecutive months in soil unable to renew its supplies of water. In order to understand what this means, imagine the state of ruin to which a metropolitan garden would be reduced were no watering permitted during the summer.

Fortunately situated exceptions are those plants able to reach down to a watertable. This may be done at comparatively shallow depths on the narrow coastal plains or in the neighbourhood of some river, creek, fresh lake, or granite outcrop, or again in the mulga country which lies on the north and north-eastern margins of the South-West Division*. But in other localities the circumstances are very different. For instance, wells and mine workings

* *See* Roy. Soc., W.A., Vol. XII., p. 124.

show that to the eastward of the jarrah belt the water is at a depth of 80 to 100 feet in much of the timber country, and in many places it is salt. Such country is occupied chiefly by associations of salmon gums and gimlet,† the height of the former being as great as, and that of the latter about half, the distance from the ground surface to the water table. Under neighbouring sandplains fresh water is often available at shallower depth, but there the vegetation is rarely over ten feet high and usually is much less. Since in ordinary plants the root system is not so extensive as the aerial parts, it follows that special modification is necessary to enable plants in summer to reach any water supplies situated at depth below the wheat belt. Even on the wettest slopes facing the Southern Ocean, noticeably where light porous soils occur such as patches included in the karri forest near Nornalup, there are many areas in which the huge trees entirely give place to comparative dwarfs such as banksias and sheoaks, and in some cases to tufts of herbage such as the formidable ‡sword-grass. These plant assemblages, included as they are in the great temperate rain forest, resemble those able to resist the summer drought of the western coastal plain. It seems certain that even on the wettest southern slopes there exist localised plant assemblages which, for at least a portion of the year, are contending with soil aridity.

The term Xerophyte is applied to plants able to flourish in arid regions. In spite of the fact that, during our winter, the South-West of Western Australia is by no means arid, the scarcity of water during the summer makes it necessary for most of the perennials to be xerophytically modified. That they actually possess such modifications may be inferred from a comparison of the manner in which, on the one hand, they withstand the seasonal drought, and, on the other, the fatal wilting of plants introduced from regions not subject to water deficiency. The native plants continue to flourish and it is not unusual to find many of them putting forth the young growth of a new season before the advent of the winter rains. In our gardens the introduced plants are saved only by repeated waterings.

An investigation of their structure or life history reveals at once that the native perennials are highly specialised and also leads to the placing of their various modifications into five main groups. These are:—

(*a*) *Abnormal absorptive structures and physiological processes.*

(*b*) *Water storage tissues.*

(*c*) *Specially efficient water distributing systems.*

(*d*) *Devices for the reduction or even stoppage of transpiration during periods of water shortage.*

(*e*) *Special powers of surviving desiccation of the cells should the previously mentioned modifications fail in their purpose.*

Each of these groups must be considered separately, but it is to be borne in mind that any individual plant may exhibit modifications belonging to one, two, or any number of the groups. Indeed, one of the fascinations of xerophytes is the diversity of their modifications, and there is quite a thrill in the first glimpse of the microscopic structure of a leaf from an arid district.

† Salmon Gum (*Eucalyptus Salmonophloia*). Gimlet (*E. Salubris*). ‡ Sword grass (*Dasypogon bromeliæfolius*).

(*a*) *Modifications for absorption.*

With regard to the special absorptive modifications, it is obvious that the purpose of the roots will be to absorb to the fullest extent, and there is evidence that the root systems of our plants are specialised morphologically in two main directions. First, the depth attained is often surprising. Instead of being somewhat less extensive than the aerial growth, the roots of mulga trees* have been encountered at depths of from 80 to 90 feet in mine workings, whereas the tree-tops are rarely more than 15 to 20 feet above the ground. Many of us remember seeing roots deep in the Yallingup caves. One, at a depth of a hundred and twenty feet, has a diameter of two and a half inches. Almost as striking an instance is afforded by the zamia palm,† which is common in the neighbourhood of Perth. In seedlings of this plant, the primary root elongates at a much greater rate than the aerial shoot. Seedlings examined when between two and three years old had but one or or two leaves reaching to a height of six or eight inches, and growth was apparently at a standstill. Digging exposed a surprisingly deep primary root. About four inches below the surface the diameter was one-fifth of an inch, rapidly tapering to one-twelfth of an inch and then maintaining this thickness for at least four to six feet, at which depth the roots did not seem to terminate, but were untraceable owing to their fragile nature and the looseness of the sand, which was dry at the time of digging. It was noted that water storage tissues were already present in the curious coralline roots and in the underground stem which was swollen to a diameter of over half-an-inch. Old palms in the same locality had up to twenty-five leaves, some reaching a height of ten feet. Their swollen underground stems, with succulent leaf bases, were approximately two feet in diameter, and the upper part of the tap-root some four inches through. How deep the roots are is not definitely known. Reports state that they have been encountered at a depth of thirty feet in wells, but I have been unable to verify this statement.

If this deep rootedness enables many plants to survive dry seasons, the question arises as to how the seedlings are enabled to survive until the roots are long enough to reach the water at depth. It has already been shown that for some years the aerial portion of the zamia palm is negligible in area and the little which is present is protected against water-loss by an efficient cuticle. Water loss is thus reduced to a minimum and as an additional precaution against death by desiccation, water storage tissues are present. In its early years it is evident that water-losing tissues are almost missing and that the energies and resources of the plant are almost wholly utilised in the rapid lengthening of the tap-root.

Such a commencement in the life history of the zamia palm may point to the reason for a similar behaviour of young jarrah plants. During reforestation operations conducted by the Forestry Department of this State, it was found that jarrah seedlings apparently become dormant after a few months of development. The period of inactivity generally lasts from three to five years, but may continue as long as ten or twelve years. Root activity has been observed, but only just below the surface of the ground where rounded woody swellings seem to indicate that the jarrah is passing through a stage comparable to that exhibited by the mature mallee. It seems reasonable to presume that the delayed development of the jarrah into the sapling and tree stages is due to the roots requiring considerable time to

* Mulga (*Acacia aneura*). † Zamia Palm (*Macrozamia Fraseri*).

reach permanent fresh water at depth. Great difficulty is encountered when any proof of this is sought, for most of the jarrah belt is unoccupied by settlers, and the timber workers and others who do live in the region obtain their water supplies without sinking wells in typical jarrah country, and so roots and water-table levels are not exposed.

Accurate water-table levels are available for four situations in the jarrah belt. Two are outposts, one being in the far south at Manjimup and the other on the western fringe at Harvey amongst the foothills of the Darling Range. At Manjimup* permanent water is obtainable in wells at depths as shallow as twelve feet, one such well with a twenty-foot drive yielding 4,500 gallons a day. At Harvey* a bore showed doubtfully permanent water at 56 and again at 80 feet below the surface, but a copious flow (40,000 gallons a day) was not secured until water-bearing strata were reached at 115 feet. The water does not rise naturally in the bore, and pumps have to be used. The jarrah should have no difficulty in reaching the water-table at Manjimup, but at Harvey, no doubt, it would take years for the roots to penetrate to a depth of 115 feet. At Jarrahdale† and at the 42-mile† on the Perth-Albany road, the water-table is reached at depths of 30 and 30 to 40 feet respectively.

In spite of the presence of this water, there is doubt concerning the ability of the tree to reach it. Many observers deny that jarrah or eucalypts in general possess tap roots. The opinion is partly based on evidence afforded by trees overturned by gales, but the destruction of these trees may have been a consequence of the local rock formation preventing the development of deep roots. Again, absence of deep woody roots does not disprove the power of reaching water at depth, for thinner fibrous roots may serve the purpose, although it would be natural to suppose that ultimately they would possess much lignified xylem tissue.

If the jarrah does establish contact with permanent water supplies there would be no need for transpiration restriction and water storage. Special modifications observed, such as the vertical habit of the leaves and peculiarities of vascular tissues, would be responses to light stimulus or means of overcoming water transport difficulties occasioned by the height of the tree and the rapidity of water loss. In the mature zamia palm, the roots of which have reached water, the large underground stem and swollen leaf bases are probably of greatest service as food reserves when the aerial portions of the plant have been destroyed by fire or other injury.

The second type of root development seems specially adapted for the rapid absorption of water from thunderstorms or other summer rains of short duration which wet the soil but for a few hours. There is an elaborate network of roots at the surface. In digging close to banksia trees this network is found right at the surface, the compact fibrous mass being removable by the spadeful. Hillside trees, overturned by gales, have also been noted to possess a very complete root network in the surface soil. This soil in many localities is completely dry for much of the summer. The spreading network of shallow roots is characteristic of many eucalypts, including the jarrah.

As regards physiological specialisation, it must be remembered that the plant roots are unable to remove all the water from the soil

* Information by courtesy of officers of the Public Works Department.

† Information kindly supplied by Mr. Munro, of Millar's Timber Co.

particles with which the root hairs come in contact. Increasingly powerful forces oppose the removal of water as the films around the particles become thinner. But it has been shown that osmotic pressures vary in the root cells of different plants and in the same root cells at different times. Therefore the thinness to which the water film will be reduced will vary according to the kind and condition of the root. It is quite possible that such variation is too small to be of much consequence, but, on the other hand, it enables saltbush roots to obtain water unprocurable by other plants. As a general rule it has been shown that xerophytes, other than succulents, have high osmotic pressures. It has been shown further that local pines may reduce the water content of sandy soils to less than two and a half per cent. of the total capacity. *Pinus pinaster* growth ceases when this figure is reached, and death occurs rapidly in young pines when the moisture about the developing roots drops below one per cent.* In the case of the pine, however, the presence of a mycorrhizal fungus complicates matters considerably.

But some of the most interesting facts concerning absorption of water are not connected with the root systems. It has long been known that numbers of plants are able to take in materials through their leaves. In this State, the sundews and the Albany pitcher plant† absorb nutritive juices obtained from small animals which they capture, and it is believed that the absorptive structures have been developed from simpler water-absorbing modifications associated with hairs and scales. Such simple structures are known to enable certain plants of the South African Karroo to absorb dew deposited on the leaf surfaces. It is not surprising, therefore, to find that in Australia there are plants with a similar habit.

In 1925 J. G. Woods published‡ the results of a research into the water absorption of plants of the genus Atriplex (saltbushes), which were flourishing in a region of from 5 to 8 inches of rainfall per annum. The saltbushes were found to have a poor root system confined to the uppermost few inches of soil. Water and mineral absorption from the soil is possible only during the short period of the year in which the surface soil is wet. Indeed, absorption takes places through temporary lateral roots which die as the soil again becomes dry. In spite of this the saltbushes were caused to appear fresh by scanty falls of rain which penetrated the soil to a negligible extent.

Shoots of the plants were placed in air 85 per cent. saturated with water vapour, and there was a definite gain of weight through absorption of water. Shoots of eucalypts and acacias, when similarly treated, actually lost water by evaporation into the incompletely saturated atmosphere about them. Further experiments were conducted in order to discover how the saltbushes obtained the water from the moist air. The solution of the problem lay first in the fact that the cells of the epidermis of the leaf were not shut off from the moist air by an impervious cuticle, but instead were covered by several layers of large bladder-like hairs or vesicles and, second, in the remarkable common-salt content of the leaves—chiefly near or in the veins towards the central parts of the leaf. The solution of this salt was sufficiently concentrated to give osmotic pressures of from 25 to 65 atmospheres

* W.A. Forestry Dept Bulletin No. 43, p. 22.

† *Drosera spp.* (over 30 in W.A.) and *Cephalotus folicularis.*

‡ Aust. Journ, Exp. Biol. and Med. Sci., v. ii., (1925).

in the different species of Atriplex investigated, whilst American figures for A. Nuttallii are as high as 169 atmospheres.* The 85 per cent. saturated air must have caused the slightly saline vesicles to become moist. The water supply so obtained was absorbed by the epidermal tissue and then passed from cell to cell in the direction of increasing osmotic pressure, ultimately arriving at the vascular tissues of the leaf.

In this manner can be explained the freshening of saltbush after light rain, dew, or even after exposure to moist air. It must be remembered that, although rain may be infrequent, dews and moist air are common even in inland and desert areas. Although in the heat of the day the air may be dry, night, with its low temperatures, brings a greatly increased humidity. The daily range of temperature may be surprisingly great, as the following instance shows: Between Kellerberrin and Kodj Kodjin, during the evening of an extremely hot summer day (the shade temperature had probably been over 110 deg. F.), water in kerosene tins was placed out in the open. The next morning, just before sunrise, the water was covered with a thin ice film. During 14 hours the fall in temperature had been approximately 80 deg. F. On the wheat belt in summer, harvesting often has to be delayed until some hours of sunshine have caused the dew to dry from the crop. The Atriplex species growing there can replenish water supplies without difficulty and it is unlikely that they are unique in this respect. Perennial grasses, growing in tufts, have crowded shoots rising amidst masses of dense hair. Moisture is retained far into the day, and deep among the hairs epidermal cells can easily forego the protection of a cuticle, and absorption would proceed apace whilst water remained in contact with the plant surface. It would be no surprise were such modification found to exist. Large and curiously shaped hairs and scales are commonly found on the leaves of indigenous plants, and absorption may prove to be one of their functions.

(b) *Water Storage Tissues.*

Leaving absorption and turning to the storage of water, first impressions would lead one to remark that water storage tissues are singularly scarce in this area of summer drought. There is certainly a dearth of succulent plants such as the *Cacti*, *Crassulaceae* and *Euphorbiaceae* so characteristic of arid lands of other continents. This may be for the reason that the succulents are not adapted for life in the driest of the earth's arid regions, and for at least some months of each year our plants are exposed to that most severe type of aridity—a combined drought of soil and atmosphere. But first impressions are not wholly correct, and numerous instances of water storage occur. Many leaves store considerable amounts of water. Amongst others, *Mesembryanthemum* species do this, the best known being *M. aequilaterale*. Borne on a creeping stem, the leaves are approximately 4½ inches in length, half an inch in diameter, and the transverse section is in the shape of an equilateral triangle. Even at the end of a dry summer and in close proximity to sand which is frequently intensely heated, they still retain their turgor, and on being trodden upon yield a plentiful supply of moisture. Smaller and even sclerophyllous leaves, such as those of the centric type of some of the hakeas, contain appreciable quantities of water. In the centre of the leaf, close to the vascular bundles, there is a considerable development

* Proc. Soc. Exp. Biol. Med. 18, 106 9 (1921).

of compact, moisture-containing parenchyma. Leaves exhibiting water storage cells are by no means rare, and all the leaves to be mentioned later in this address (figs. 9 to 13) possess tissues which serve this purpose.

Stem storage of water is even less obvious than leaf storage, for in many cases it is an underground stem which is capable of holding the water reserves. *Macrozamia Fraseri* has already been alluded to in this connection, and kangaroo paws (*Anigozanthos* spp.) often develop a moist-tissued rhizome. The common local paw (*A. Manglesii*) is a familiar example.

Mesembryanthemum aequilaterale may again be mentioned, for the creeping stem contains much water to supplement that contained in the fleshy leaves.

(c) *Specially Efficient Water-distributing Systems.*

Special modifications of this nature are mainly exhibited in leaves. In an ordinary plant the older roots and woody stems are almost entirely composed of vascular tissues and protective systems, so there is not much scope for additions to the vascular tissue of those portions of the plant. On the other hand most of our plants show exceptional development of leaf venation. The veins and associated fibres form an unusually large proportion of the whole leaf. The distribution of veins is such that no cells are removed an appreciable distance from xylem tissue. It is often the case that the cells immediately in contact with the xylem are soft-walled and enlarged, and serve as water storage tissues actually in contact with the palisade and other cells adjacent to the stomata through which water loss must take place. Indeed, the leaves seem planned largely for ensuring a rapid and abundant water supply to the chlorophyll containing cells, always provided that water is being delivered to the leaf sufficiently rapidly by the absorbing and transporting systems of the root and stem. The leaves themselves, particularly those able to transpire freely, play a large part in securing their water supply. It has been shown that in the early stages of water shortage, supplies of moisture may pass to exposed leaves from shaded leaves or from fruits. In the case of the apple, it has been shown in this State by Mr. W. M. Carne that the withdrawal of water from the fruit may be great enough to injure the tissues, the condition known as water-core resulting. It seems that some of the characteristics of xerophytes are exhibited by any plants so tall that considerable effort is needed to raise water to the tree-tops. In such cases, the highest leaves show the greatest degree of modification and at least some of the xeromorphic structures function in providing the leaf cells with a sufficiently rapid water supply to make good the losses due to vigorous transpiration.

(d) *Devices for control of transpiration.*

On approaching a description of the devices for minimising water loss, one is faced with a surprising wealth of material. Although, as has been shown, there is considerable specialisation for absorption and storage, the south-west Australian plants seem to have solved the aridity problem largely by thoroughness in water thrift. Sometimes it is a matter of specialised habit of the whole plant. More frequently it is an elaborate guarding of surfaces from which water escape is possible.

Specialised habits may be observed where winds are characteristically dry. There is often a definite transpiration limiting tree-top pattern. It

is conspicuous on the wheat belt and goldfields, notable instances being afforded by the salmon gum, the morrell (see fig. 3), and various mallees. The leaves, of which there are surprisingly few, are grouped in saucer formation, convex curve uppermost, revealing in full the gaunt strength of trunk and limb. Full exposure to intense light enables photosynthesis to proceed unrestrictedly, but the dry winds pass with a minimum of effect. Another general habit enabling plants to escape some of the effect of the drying wind is the stunting which is specially evident on porous sandplains or towards the desert fringes. Creepers such as *Mesembryanthemum aequilaterale* and *Kennedya prostrata* also take advantage of this manner of modification.

But it is easily ascertained that such general habits as stunted stature or tree-top patterning are not in themselves sufficient protection against water loss. The whole of the exposed surface of the plant has to be rendered frugal as regards water. The glint of light from the leaves of salmon gum and mallee gives evidence of this and so does the tough cuticle of *Mesembryanthemum aequilaterale.* Hairs form the protection of some plants. Plants of the genus *Lachnostachys* are entirely clothed with dense woolly hair and so acquire names such as "lambswool" or "flannel plant." In one specimen, stems which appeared to be one centimetre in diameter were found in reality to be barely a millimetre through. Nine-tenths of the apparent diameter were composed of a furry mass of hairs. The leaves and inflorescences are similarly covered. Just as a fierce gale fails to expend its full force on a person sheltering in a dense thicket, so the strongest winds cause but little renewal of air outside the hair-protected stomata and transpiration is minimised. On rubbing the stem a resinous smell is noticeable giving evidence of further protective modification. Larger plants have corky coverings or persistent leaf bases (*Macrozamia Fraseri, Xanthorrhea preissii*) protecting their stems and all but the youngest parts of the branches, so it is the stem-tips and leaves which exhibit the structural modifications usually associated with xerophytes. The leaves are particularly interesting and a study of them leads to a strengthening of the claim that the Angiosperms owe their present-day dominance in the vegetable world to the facility with which leaf modification takes place. Difficulties of environment are time and again surmounted by appropriate leaf modification. Numerous outstanding instances may be quoted such as the carnivorous leaves of sundews and pitcher plants, the tendrils of the sweet-pea and the phyllodes of acacias; but it is difficult to imagine leaf modification achieving more for a plant than fitting it to live in a desert or a region of seasonal drought, such as ours.

It must be remembered that, except in the case of submerged plants, transpiration is an essential process. Minerals which must be obtained from the soil can only enter when dissolved in soil water. Moreover they can reach the leaves at an adequate rate only if the water is passing freely through the plant, leaving it by evaporation chiefly at the leaf surfaces. There is another reason why it is not in the interest of the plant to restrict transpiration. Free interchange of gases with the atmosphere for respiration and photosynthesis is necessary if growth and other plant activities are to proceed. This interchange takes place chiefly through the stomata of the leaves and can occur freely only if those pores are wide open. Therefore, any checking of transpiration accomplished by closing the stomata will re-

sult in a more or less complete cessation of breathing and nutrition and plant activities will cease. In this fact may be the explanation of the stunting so characteristic of the plants of arid regions. In times of water shortage the plant has to suffer one of two hardships. Either transpiration is checked and all activities are reduced, or the stomata are kept open and its cells exposed to the risk of desiccation. Except in the case of certain remarkable plants whose tissues can actually become air-dry without fatal results, excessive desiccation results in death. The plants, in order to survive, must take steps to check evaporation even at the sacrifice for the time being of all normal activities.

At the onset of drought, quite a number of transpiration-controlling devices may be brought into operation and still others seem to be permanent, possibly having been almost imperceptibly acquired over long periods of time during which a gradually progressive climatic desiccation was proceeding or whilst the plants were slowly spreading into drier areas. The chief transpiration-controlling devices may be classified as follows:—

(i.) Leaves degenerate or disappear so that transpiration, occurring at stem surfaces, proceeds more slowly. This is due to a reduction of green surface and, or else, to a diminished number of stomata per unit area. Members of the genus *Casuarina* exhibit this leaf degeneration.

(ii.) Leaf surface, when present, is reduced by:
- (a) A lessening of the number of leaves by shoots developing into thorns instead of foliage bearing branches, by a rigorous natural pruning, or by shedding many leaves at the beginning of summer;
- (b) replacement of complete leaves by phyllodes as in many of the acacias.
- (c) A diminution of leaf size. Many of our plants are microphylls, saltbushes and bluebushes (*Kochia spp.*) being examples;
- (d) leaves becoming narrower as in the Geraldton Wax* plant or the centric leaves of some of the hakeas. This, as in (c), results in the photosynthetic tissues being close to the vascular system from which the water supply is received;
- (e) leaves, and even large parts of the aerial system, wilting and eventually dying during prolonged droughts. Subsequent rains cause shoots to arise from the base of what was apparently a dead plant. This behaviour has been observed in the saltbush and bluebush along the Transcontinental Railway and has a parallel in the regular dying back of the aerial parts of orchids and droseras in early summer.

(iii.) Leaf surface in general is protected against drying in wind or still air by:—
- (a) Low stature, either by dwarfing shown by sandplain plants or by assuming a creeping habit.
- (b) Treetop patterning as shown in fig. 3.
- (c) A covering of cuticle, bloom, hairs and scales and gummy substances.

* Geraldton Wax (*Chamaelaucium uncinatum.*)

(iv.) The stomata are protected against water loss by:—

(a) Occurring more numerously or entirely on the under surface of the leaf. (Figs. 11 and 12.)

(b) Being sunk below the general level of the leaf surface (fig. 13). The lower the stomata, the slower is the rate of diffusion through them.

(c) Permanent undercurling of leaf margins. The stomata being only on the under surface, are shielded from air currents. This is the case in Banksia attenuata.

(d) Occurring only on hair- (fig. 12) or scale- (fig. 9) protected surfaces.

(e) Occurring only in flask-shaped cavities opening by narrow pores, perhaps hair-plugged on the under surface of the leaf. (*Dryandra floribunda.*†)

(f) Leaf rolling, as water becomes deficient, whereby the stomata no longer open to the free air but to the air in a closed compartment. (Figs. 11 and 12, also various grasses.)

(g) Control of stoma size by movements of guard cells.

(v.) Soft parenchymatous tissue is replaced by sclerenchyma or other mechanical tissue, such as spicules, especially near the leaf surface. (Fig. 13.)

This, together with the great development of vascular tissues, causes plants to have leaves of harsh texture, many feeling like chips of wood. Thorns, prickles and general harshness often make it a matter of difficulty and discomfort to force a path through uncleared country. The decrease of parenchyma lessens evaporation within the leaf, and the increased mechanical tissue gives a rigidity which minimises bending and distortion of the leaf in the wind, thus removing one cause of the movement of gases in and out of the stomata.

This rigidity also causes the leaves of many plants to show no outward signs of collapse as wilting proceeds. They escape the fate of more membranous types which, becoming soft and flabby as water loss occurs, are torn to pieces by strong winds.

(*e*) *Special powers of surviving desiccation should other modifications fail in their purpose.*

The possession of powers of this nature is better known in cryptogams than in higher plants. Mosses may be brown and dry for long periods, and yet recover in a matter of minutes when covered with water. In other plants it has been shown that the fatal effects of desiccation are not due so much of the actual dying, but to rupture of the protoplasm as it contracts away from the cell wall. In some cases it seems that this shrinkage is accomplished without mechanical injury, and the return to moist conditions results in the swelling protoplasm regaining its normal activity. The ultimate explanation will probably be discovered by the colloid chemist, and to

† For section of leaf, *see* Jour. Roy. Soc., W.A., Vol. VII., p. 105.

him also it will be given to explain the properties of hydrophilic colloids which enable the protoplasm of otherwise unprotected cells to retain moisture in spite of conditions which tend to promote rapid transpiration.*

In order to illustrate the nature of some of the modifications which have just been mentioned, drawings of transverse sections of leaves, picked more or less at random, and from the upper parts of plants, near inflorescences, will be projected upon the screen. The first six were gathered between Yelbini and Dowerin (figs. 8 to 13), whilst the remainder were obtained in the neighbourhood of Perth. (See Jour. Roy. Soc. W.A., Vol. VII., pp. 105-107.)

The transverse section of *Pimelia sulphurea* (fig. 8), is that of portion of an isobilateral leaf with the upper palisade layer developed better than the lower. The outstanding feature is the provision of water storage tissues, the epidermis and the centrally placed parenchyma serving in this respect. Vascular tissue is also prominently developed, the veins forming a small mesh network. Water transporting facilities are therefore quite good. The terminal portions of the xylem vessels are considerably dilated (as at X). In many places, curvature of the palisade cells indicates their dependence on a ready supply of water.

The cuticle is but moderately thick, and this fact, together with the unprotected nature of the stomata, points to physiological rather than morphological restriction of transpiration, though it must be noted that the mesophyll is more compact than porous and internal evaporation will be retarded.

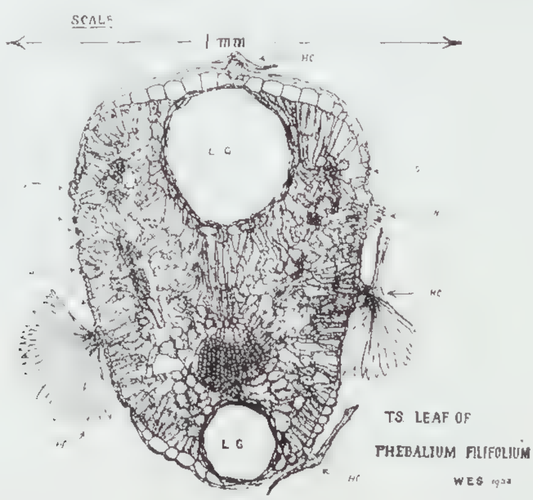

Fig. 9.—T.S. leaf of *Phebalium filifolium*, collected near Dowerin.
C, cuticle; E, epidermis; H, hair; H.C., scale; L.G., lysigenous gland; P, palisade tissue; S, stoma; Scl., sclerenchyma; S.H., stellate hair; S.H.B., stellate hair base; Sp., spicule; S.P., spongy parenchyma; V, vascular bundle; X, dilated termination of xylem vessel.

Fig. 9, a transverse section of the leaf of Phebalium filifolium, shows several striking modifications. In the first case the ratio of leaf surface to volume has been reduced by a great lateral compression of the leaf. The usual lateral expansions of the lamina are missing, and this change has been brought about chiefly by a reduction of the upper surface. As a result, the lower surface and the network of veins are no longer in horizontal planes, but have been bent steeply upwards along and on either side of the midrib. As a consequence, the original under surface forms the two sides of the

* *See* "Application of Colloidal Chemistry to Agriculture," by R. A. Gortner, Colloid Symposium Monograph Univ. Wisconsin, 1923.

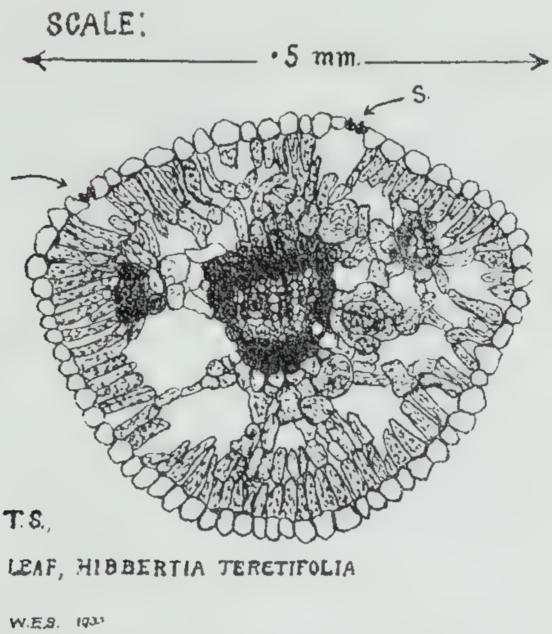

Fig. 10.—T.S. leaf of *Hibbertia teretifolium,* collected near Wyalcatchem.

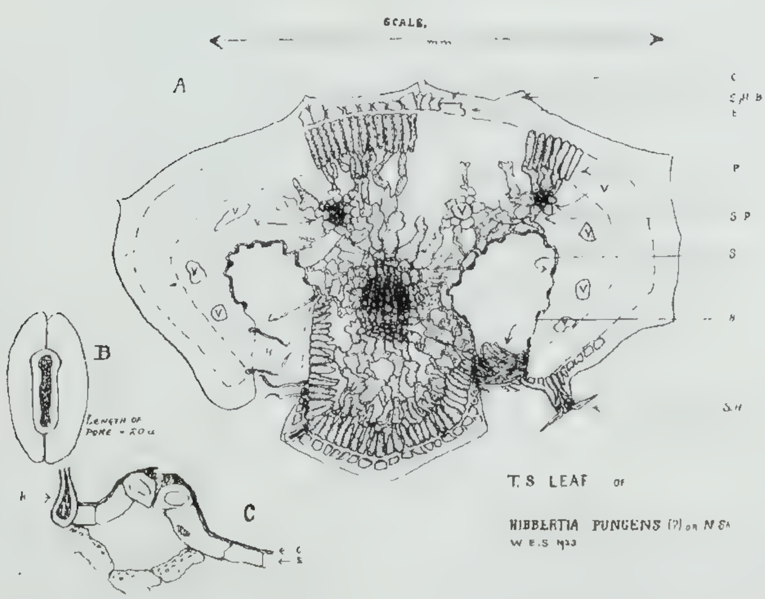

Fig. 11.—A, T.S. leaf of *Hibbertia pungens* (?), collected near Wyalcatchem, and almost touching *H. teretifolium.* B and C, stomata more highly magnified.

C, cuticle; E, epidermis; H, hair; H.C., scale; L.G., lysigenous gland; P, palisade tissue; S, stoma; Scl., sclerenchyma; S.H., stellate hair; S.H.B., stellate hair base; Sp., spicule; S.P., spongy parenchyma; V, vascular bundle; X, dilated termination of xylem vessel.

leaf, with the stomata in dangerously exposed positions. In spite of this, excessive transpiration is prevented by a thick growth of large parasol-like scales (HC), which overlap in such a manner as to completely shade the otherwise unprotected lateral surfaces of the leaf. The upper and lower surfaces (especially the upper) are amply protected by a thick cuticle and a scanty covering of somewhat smaller scales. Internally, mechanical tissues are almost missing, and the centrally placed portions of the mesophyll appear capable of storing some reserve of water. Lysigenous glands, similar to those of other plants of the *Rutaceae,* occur in two rows, one immediately below the upper epidermis and the other just above the lower surface of the leaf.

Figures 10 and 11 are exhibited as a contrast. The leaves came from neighbouring bushes (practically touching) about four feet high, with flowers and habit so similar that at first it was thought the plants were of the same species. The leaf arrangement was then noticed to be different and, later, the microscope revealed the remarkable contrast shown in the illustrations. The leaf of *Hibbertia teretifolia* is certainly an enigma. Apart from its general form there is nothing xeromorphic to be seen. Cuticle is singularly deficient, stomata are totally unprotected, and the mesophyll is comparatively porous. Yet it survives intensely dry summers, and flourishes as well as its close relative with leaves protected in the efficient manner disclosed by fig. 11. High osmotic pressures or hydrophilic colloids may give the leaf tissues the power to hold water against transpiration, but no evidence of this is available.

The leaf which has been doubtfully identified as that of *Hibbertia pungens* is almost ideally xeromorphic. It has an upper surface which appears completely waterproof. A few stellate hairs are probably survivals of a more complete covering possessed in earlier stages of development. The stomata occur only on the under surface, and each has a special protection against too rapid diffusion. A collar-like ridging of the cuticle of the guard cells forms a partially enclosed chamber, as shown in fig. 11, diagrams B and C. But the chief modification shown by the leaf is its power to adapt itself to variations in the rates of water supply and loss. If the former exceeds the latter, the leaf is broad and flat, and transpiration and oxygen and carbon-dioxide diffusion proceed unrestrictedly. On the other hand, when the rate of water loss dangerously exceeds that of supply, the spongy parenchyma of the lower part of the leaf becomes smaller. No such shrinkage occurs along the thick cuticle, and the leaf becomes rolled as in Fig. 11A. Hairs are developed in restricted bands along the under margins of the leaf and along the sides of the prominent midrib. As shown in the diagram at H, these mingle closely, with the result that all the stomata open into what is virtually a closed compartment, and transpiration practically ceases. *Hibbertia pungens* (?) exhibits a flexibility of modification which is the highest degree of xeromorphism. During the wet months of the year gases are able to pass freely in and out of its leaves, but the onset of the summer drought causes a complete change in this respect, although the temporary water supplies afforded by thunderstorms are able to be availed of.

Lysiosepalum involucratum (see fig. 12) possesses a leaf with rolling powers similar to those of *Hibbertia pungens* (?), but it will be observed that in this case the lamina has hinges reminiscent of those of rolling grass leaves. A special feature is the provision of a dense layer of stellate hairs

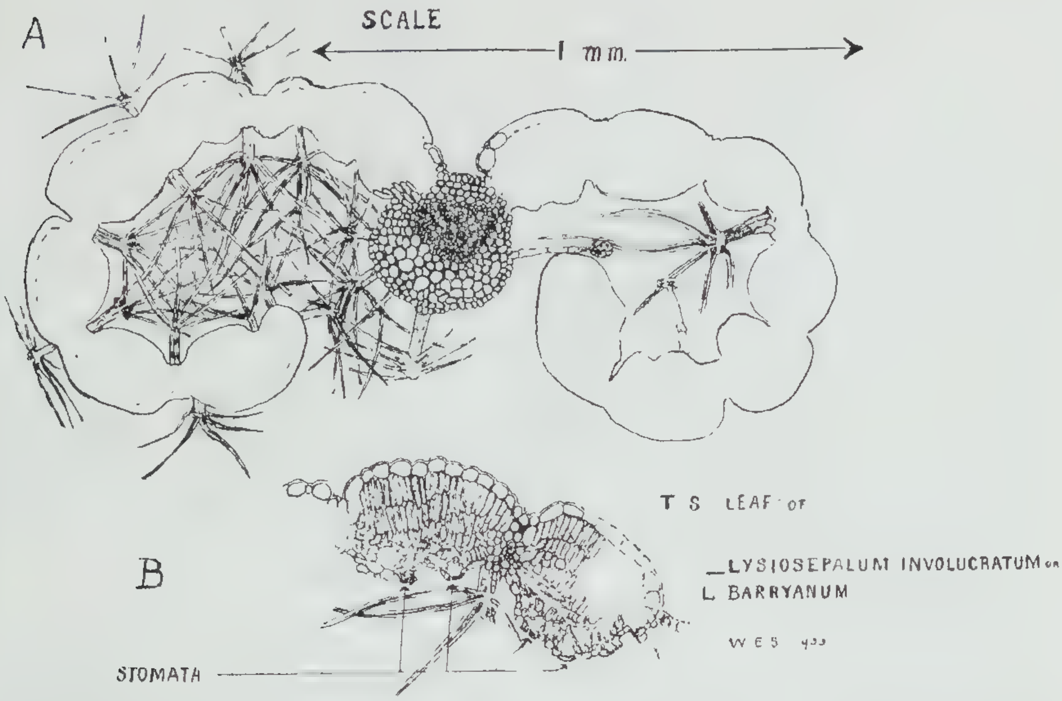

Fig. 12.—A, T.S. leaf of *Lysiosepalum involucratum* (Turcz), Gardner, combined *L. Barryanum*, collected near Dowerin. B, Portion of leaf more highly magnified.

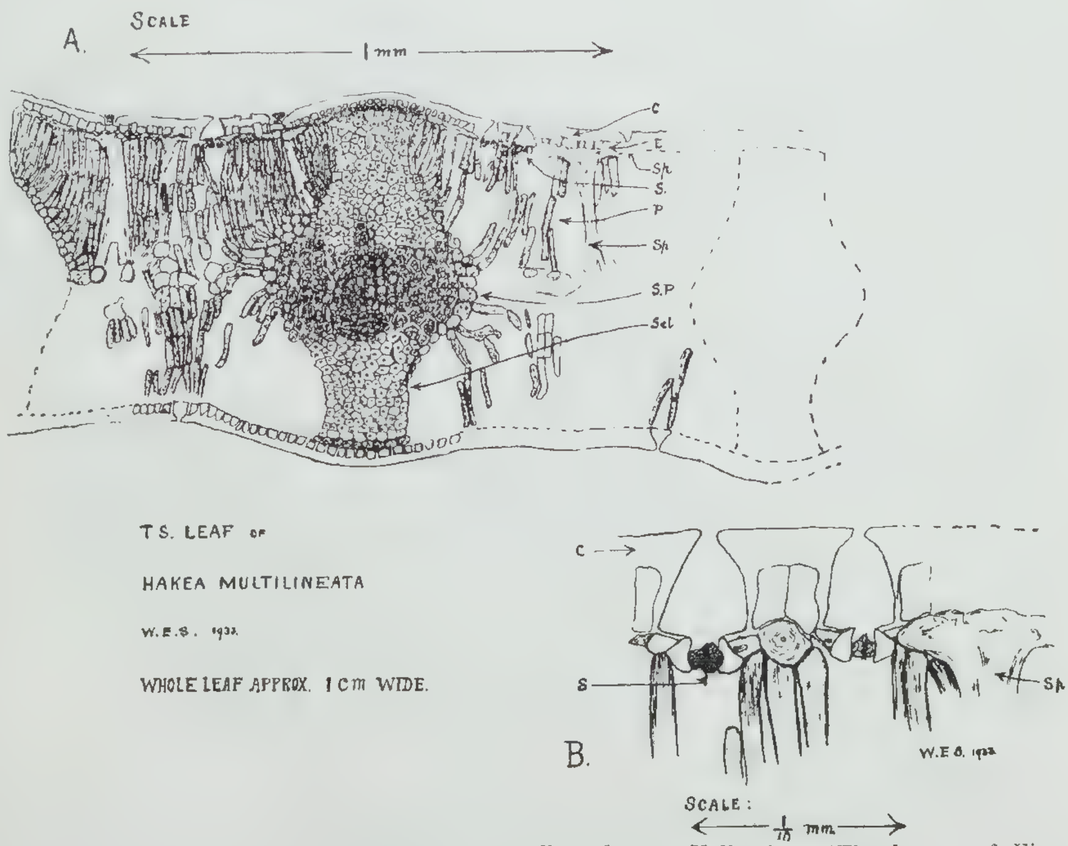

Fig. 13.—T.S. leaf of *Hakea multilineata*, collected near Yelbeni. (The leaves of Figs. 8, 9, 10, 11, 12, 13 were identified by C. A. Gardner.)

C, cuticle; E, epidermis; H, hair; H.C., scale; L.G., lysigenous gland; P, palisade tissue; S, stoma; Scl., sclerenchyma; S.H., stellate hair; S.H.B., stellate hair base; Sp., spicule; S.P., spongy parenchyma; V, vascular bundle; X, dilated termination of xylem vessel.

able to minimise transpiration both when the leaf is broadly open and when it is rolled. Amongst the stellate hairs are others which appear glandular in nature.

Hakea multilineata has long broad leaves, flat and ribbed. Mechanical tissue is strongly developed in girder form above and below the vascular bundles, and spicules are present (sp., Fig. 13), their basal portions extending as a protective layer between the epidermis and the palisade tissue. In the sclerenchyma girders, a curious tissue occurs on either side of the vascular bundle. The disposition of the adjoining parenchyma indicates that the tissue is able to convey water, but histologically there is nothing to substantiate this unless the thick cell walls are freely permeable. Within each cell wall, in some cases the protoplasm seems highly vacuolated, whilst in others there appears to have been a division into many rounded cells without any corresponding formation of cell walls. The upper and lower surfaces of the leaf exhibit no differences. Each is efficiently protected by a very thick cuticle (see diagram B, fig. 13), and the stomata are deeply sunk in conical chambers which open to the exterior by very minute pores.

It his been objected that the structural modifications that have just been mentioned are of doubtful significance, chiefly for the reason that some of the highly specialised plants are found in the perennially wet soils adjoining permanent creeks and soaks. The objection is not a valid one. It might similarly be held that the down-growing branches of fir trees and the deciduous habit of the apple have no significance because those plants retain their modifications when growing in the region of Perth, where snow and other winter rigors do not occur. The point to be emphasised is that certain special modifications enable some species of plants to survive more or less prolonged periods during which supplies of suitable water are unavailable or available at a rate less than necessary for the survival of other terrestrial species. All the plants of the specially modified species are not restricted to dry localities, any more than a fir tree is restricted to lands of snowstorms. Seeds of such species may germinate beside a stream, and generation after generation enjoy continuous and copious supplies of water. At length, the xerophytic modifications which control water loss may disappear, but no more rapidly than the apple and the plum are losing the deciduous habit. Neither does it follow that the xerophytes will prove unequal to the competition of the mesophytes already established beside the stream. Particularly does this apply to those possessing flexibility of modification, such as mechanism for leaf movement, for when water is freely available they are capable of rapid transpiration and are able to take the greatest advantage of moist conditions. In other words, the most highly modified xerophytes may grow side by side with the mesophyte in the environment of the latter, but their special nature is shown only when they grow and thrive in regions permanently or periodically too arid for the existence of plants lacking the special modifications which they possess.

It can be stated with assurance that the vast majority of our South-West Western Australian plants possess this special nature in greater or lesser degree, and it is the display of diverse modifications and life-histories such as have been mentioned to-night that constitutes the response of plants to the dry phases of our climate.

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Vol. XIX.

1.—SARCOSPORIDIA.

By G. Bourne.*

Read 9th August, 1932; *Published 12th December*, 1932.

INTRODUCTION.

Sarcosporidia are, as their name implies, parasites of muscle. Their systematic position is uncertain. They are customarily placed among the Protozoa, Wenyon (24) regarding them as parasites of undetermined position.

The first discovery of Sarcosporidia was made in 1843 by Miescher. They were observed in mice and for some time were called Miescher's tubes. Rainey was the next observer, and he found the parasites in pigs in 1858, but regarded them as young forms of *Cysticercus cellulosae*. Leukhart corrected the mistake and showed that the parasites were closely related to the *Myxosporidia*.

Wenyon (24) commented on the fact that Ashworth showed the *Rhinosporidia* were fungi, and suggested that the *Sarcosporidia* may be of a similar nature.

Sarcosporidia are commonly found in voluntary muscle, but may occur in involuntary and heart muscle. The Sarcocyst elongates within the fibre at the expense of the muscle substances, which is destroyed in the process. In such a way a single parasite may grow to several millimetres in length. Occasionally the parasites become calcified *in situ*.

It is debatable whether the Sarcocyst found within the muscle fibres may be regarded as a single parasite; it is more usual to regard this period as a cyst stage, for a minute examination shows that the contents are divided up into sickle-shaped bodies which are regarded as spores.

McGowan (17) described the cuticle of the Sarcosporidial cyst as being covered on the outside with cilia which interpenetrate the muscle fibre substance. Immediately beneath the cuticle is a layer of cells which is supposed to be sporoblastic in nature, the component cells by successive divisions produce immature sickle-shaped spores which later ripen. The sickles near the centre of the cyst seem to lose their chromaticity and degenerate. The cuticle

* Submitted in partial fulfilment for the degree of M.Sc. in the University of Western Australia.

of the cyst is regarded by some authors as containing a number of fine pores, which are, however, too small to allow the sickles to escape. Under higher magnification McGowan showed the sickle possesses a well-defined structure. Almost one-half is occupied by a dark non-granulated zone, and the other half, which is full of granules, contains the nucleus.

Balfour (1) found that the Sarcocyst of the Gazelle possessed two kinds of spores, which stained differently with Toluidin Blue.

Wenyon (24) states that Alexieff considered the Sarcocyst to be composed of a large number of uninucleate parasites, and that the membrane which encloses them and the septa which divide them up into chambers, have been derived from the host.

According to Fantham (7) the stage during which the parasite elongates within the muscle fibre is known as the Trophozoite stage, and the contents, the sickle-shaped spores, represent the Sporozoite stage.

The residual masses of protoplasm which are left when the sickles are formed, and which by successive divisions produce further sickles, are known as pansporoblasts.

McGowan (17) found that on degeneration of the sickle, the contained chromatic granules are set free, and he regards these as the infective agents of the Sarcocyst.

Braun and Lühe (2) stated that the spores of the *Sarcosporidia* of mice have been found to be motile, "progressing in a series of screwing jerks."

DEVELOPMENT.

Numbers of experiments have been carried out by various authors in order to ascertain the mode of development of the Sarcocyst. Mice have been fed with meat infected with *Sarcosporidia* and the presence of Sarcocysts in the voluntary muscles has been noted about forty days after the meal. The manner in which the Sarcocysts proceed from the alimentary canal to the voluntary muscles is not definitely known, but McGowan (17) suggested that the small chromatic particles in the sickle may be set free on degeneration of the Sarcocyst, and may travel through the tissues to the voluntary muscle fibres. He quotes the experiment of Van Betegh and Dorisch, who fed ducks on the *Sarcosporidia* of sheep and found early stages of the parasite in the musculature of the stomach, each stage being composed of three chromatin particles, associated with a mass of protoplasmic material. McGowan considers that if these small chromatic particles can wander into the stomach muscles, there is nothing to stop them wandering into a fœtus in utero. Stockman (20) and Gaiger (8) consider this possibility as being extremely unlikely.

Wenyon (24) considers that the rupturing of the spore membrane liberates a small amœbula type of body, which effects an entrance into the intestinal cells. These persist only for a few days during which they undergo a period of multiplication in the region of the gut and then disappear; reappearing sometime later, about forty days, in the muscle fibres.

Fantham (7) gives an account of the descriptions of Erdmann and Crawley on the development of the Sarcocyst.

According to Erdmann, the spore on ingestion by the host, germinates, thereby liberating its contained toxin, which by its action on the surround-

ing epithelial cells, enables the amœbula which forms from the spore, to enter the intestinal lymph spaces, and then proceeds, after resting for about a month in these spaces, to the muscles.

Crawley considers that the spore or sickle is able to penetrate the epithelial cells by boring, and that once inside, it loses its sickle shape and rounds up, and that it may in this stage undergo multiple fission, and that, in fact, its appearance suggests such an occurrence. This worker believes that the spores are sexually differentiated.

The young forms of the Sarcocyst appearing in the muscle fibres at the end of forty days, are small and contain very few nuclei. These increase in number and then, according to Wenyon (24), the mass of protoplasm divides itself off around each nucleus, and a number of spores are formed equal in number of the nuclei.

When the Sarcocyst has finally destroyed the muscle fibre in which it lies, it breaks the sarcolemma and its own membrane and comes to lie free in the connective tissue of the muscle, when the spores proceed to infect other muscle fibres.

OCCURRENCE IN HOST.

The *Sarcosporidia* in Mammals, occupy chiefly the muscles of the œsophagus and larynx, and the diaphragm and body wall. In acute infections any of the skeleton muscles may be infected, even the eye, tongue, and cardiac muscles.

PATHOGENICITY.

Sheep commonly show the presence of Sarcocysts in their voluntary and involuntary muscle fibres, but these do not appear to cause any noticeable ill effects. McGowan held the theory that a particularly heavy infection may cause a sheep disease which is known as "Scrapie" in England, "Traberkrankheit" in Germany, and "La Tremblante" in France. Gaiger (8), however, has come to the conclusion that *Sarcosporidia* have no connection with this disease.

One of the commonest of Sarcosporidial infections in sheep is that caused by the genus known as *Balbiana*, which causes tumours in the œsophagus of the infected animals. *Balbiana* has been found in Western Australian, New South Wales, Victorian, and New Zealand sheep. The form known as *Balbiana gigantea*, is believed to be the same as *Sarcocystis tenella* (Raill) which is frequently found in the skeletal muscles of sheep.

Since *Sarcosporidia* are common in sheep and they are known to secrete a very virulent toxin it is possible that even a very small infection may have a deleterious effect on the good health of the infected animal, perhaps weakening its resistance and making it more liable to other infections, or dietary deficiency. No symptoms resulting from Sarcosporidial infection have been observed in Western Australian sheep.

The Sarcocyst infecting mice is very deadly. The author observed that a mouse infected with *Sarcosporidia* assumed a semi-waddling gait, as if its hind legs had been broken, that it became very swollen and puffed up, and eventually died.

Little is known of the effect of other *Sarcosporidia* on the animals infected. In one of the cases of human infection recorded by Wenyon (24) the subject complained of pain in the muscles concerned. It is possible that Sarcosporidiosis may occur more often than is suspected in human subjects.

TRANSMISSION OF SARCOSPORIDIA.

One can easily understand how Sarcosporidiosis is spread in carnivorous animals, but the specificity of the infection is not known. Attempts have been made by various workers to infect themselves by eating raw Sarcosporidial meat, with no effect. Mice, on the other hand, have been infected by feeding them with meat containing *Sarcocystis tenella,* which is normally found in sheep, and also by feeding with mouse flesh normally infected with *Sarcocystus muris* (the mouse Sarcocyst) so that in the case of mice the infection is not always specific.

In herbivorous animals a number of difficulties occur in attempting to explain the transmission. It seems possible, however, that the spread may be caused through the animals accidentally eating with their food, the droppings of infected animals.

Ticks and biting insects of various sorts have been blamed for spreading Sarcosporidiosis.

SARCOCYSTIN—THE TOXIN SECRETED BY THE SARCOCYST.

The Sarcosporidia are the only Protozoa from which a definite toxin has been extracted, and this toxin acts in many ways similarly to that of Bacteria.

Teichmann and Braun (22) state that the discovery of a toxin produced by *Sarcosporidia* was made by Pfeffer in the year 1889.

Teichmann (21) working on the Sarcosporidia of sheep, discovered that they contain a poison which is particularly toxic to rabbits. He found that the lethal dose for rabbits was 0.0002 gm. of the dried Sarcocyst. The action appears to be on the central nervous system and to affect in some way the contained lipoids. The toxin appears to be destroyed by heating to 100 degrees centigrade.

Teichmann (21) also found that this toxin could produce both active and passive immunity in rabbits, but that the toxin could not be separated from the antitoxin in a neutral mixture.

Teichmann and Braun (22) give the following list of properties of Sarcocystin:—

(a) It is thermolabile;
(b) Filterable;
(c) Soluble in physiological salt solution;
(d) It is only toxic for rabbits, not for other animals. The natural immunity of these has nothing to do with the antitoxic capacity of their serum.

These two authors show that Sarcocystin is composed of two entities, one toxic in action which is destroyed by heating to 60°C., and the other which causes hæmolysis in the blood of sheep, guinea pigs, horses, and doves, but not rabbits, is not destroyed at this temperature.

The authors also state that immune serum contains complementary antibodies against the Sarcosporidian extract.

SYSTEMATIC POSITION OF THE SARCOSPORIDIA.

The group is placed by most authors amongst the *Neosporidia*. Castellani and Chambers (3) place them as the fourth order of the Neosporidia, as do Braun and Lühe (2). Kisskalt and Hartmann place them provisionally among the *Cnidosporidia*.

Both Minchin (18) and Hartog, in the Cambridge Natural History (11), and Daniels and Newham (4) stating that it is the continuous formation of spores, without the destruction of the formative cells, which separates the *Sarcosporidia* from the associated forms of the *Myxosporidia* which occur in fish.

Wenyon (23) considers the *Sarcosporidia* to be parasites of undetermined position, and even suggests that they may be fungi.

The classification given by Hartog in the Cambridge Natural History (11) is as follows:—

PHYLUM, PROTOZOA.

CLASS, SPOROZOA.

SECTION B, NEOSPORIDIA.

ORDER 3, SARCOSPORIDIACIAE.

"Encysted parasites in the muscles of Vertebrates, with a double membrane, spores simple."

RECORDED NUMBER OF SPECIES.

Wenyon (21) records thirty nine species of Sarcocystis up to 1926. Of these twenty-eight have been found in Mammals, of which one species, *Sarcocystis darlingi* (Brumpt, 1913), has been obtained from a Marsupial, an opossum. Nine have been found in Birds, and two in Lizards.

AUSTRALIAN OCCURRENCE.

Sarcocystis miescheriana (Kuhn) has been found in pigs in Western Australia and other States of the Commonwealth. *Balbiana gigantea* (= *Sarcocystis tenella*), which causes œsophageal tumours, has been found according to Johnson and Cleland (13), in sheep in New South Wales and Western Australia. The authors consider that the latter sheep were probably imported from Victoria. *Sarcocystis tenella* is common in the skeletal muscles of sheep in Western Australia.

Johnson and Cleland (13) record the following *Sarcosporidia*:—

Sarcocystis miescheriana (Kuhn), Muscles of Western Australian pigs.

Balbiana gigantea (*Sarcocystis tenella* (Raill)), in New South Wales and Western Australian sheep.

Sarcocystis blanchardi (Dofl), in cattle in New South Wales; affecting tongue and heart muscles.

Sarcocystis muris (Blanch): Recorded from Sydney in *Mus rattus* and *Mus decumanus*.

Gilruth (10) records *Sarcocystis* Sp. in the muscles of sheep and cattle in New South Wales and in Victorian sheep, infecting the tongue. He also records *Balbiana gigantea* from New Zealand sheep.

Gilruth and Bull (9) record *Sarcocystis macropodis* from *Petrogale*, and *Ileocystis* and *Lymphocystis* from *Macropus* Sp.

There appears to be some confusion concerning the presence of Sarcosporidia in Marsupials. A number of European authors state that Sarcosporidia have been found in the Kangaroo, but Wenyon's only record up to 1926 in Marsupials is that of their occurrence in an Opossum, and the specimen *Sarcocystis macropodis* recorded by Gilruth and Bull from the Rock Wallaby *Petrogale* was in the form of cysts in the submucosa of the stomach and did not occupy the more usual position in the actual muscle fibres. Searches through the Australian Science abstracts from 1922 to 1932, the Zoological records from 1864 to 1932, and the Biological abstracts from 1926 to 1932 have not revealed any further reference to Sarcosporidia in Marsupials, so, presumably, the origin of the statement comes from the record of *Sarcocystis macropodis* from the *Petrogale*.

Tiegs (23) records a new species, *Sarcocystis pythonis* from the Australian Carpet Snake (*Python spolotes*).

PROBABLE NEW OCCURRENCE IN WESTERN AUSTRALIA.

One of a number of white mice which were supplied to the author by Dr. H. W. Bennetts, D.V.Sc., for experimental X-ray work, showed the presence in the thigh muscles of definite Sarcosporidia, which were considered, for the following reasons, to be the Mouse Sarcocyst:—

Sarcocystis muris:

(1) The mouse assumed a very peculiar gait, eventually became puffed up and died. This extreme pathogenicity is characteristic of *Sarcoystis muris* in mice.

(2) The parasties were present in the thigh muscles, the usual site of infection for this species of Sarcocyst.

(3) The parasites had grown along the muscle fibre to a relatively enormous length, that is 2 to 4 cms.

(4) The spores measured $14\mu \times 2 \cdot 7\mu$, which is within the limits of variation for this species of Sarcosporidia.

Sarcocystis muris has not previously been found in Western Australia, and although this is the first record of its presence here, it is not yet definitely known to be endemic, since the mouse in which it has been found was a descendant of stock originally sent from South Australia. The parasite is therefore probably imported.

RECORD OF A NEW SPECIES OF SARCOSPORIDIA FOR WESTERN AUSTRALIA.

In sections of muscle from the back of a Western Australian Marsupial (*Bettongia grayi*) a Sarcosporidian was found occupying the muscle fibres, which has been regarded as a new species.

This is the first record of one of these parasites in the Western Australina Marsupial fauna, and the first record in the skeletal muscles of an Australian Marsupial.

The infection was localised, but heavy. It occurred on the back muscles to the left of the vertebral column, but not on the right, just cranial to the region where the tail sinews join the back muscles.

Unfortunately the parasites were not known to be present until the sections had been made and mounted, so that there was no tissue available in order to make a detailed examination of the spores.

From an examination of the sections, the spores appeared to be sickle-shaped, that is, they were typically Sarcosporidian in form. Some of the

parasites reached up to a centimetre in length and appeared to be made up throughout their length of a mass of spores. There is very little data on which to erect a new species, but as the majority of Sarcocysts appeared to have been classified according to the host infected, the name *Sarcocystis bettongiæ* is therefore suggested for this new Sarcosporidian from Western Australia.

Sarcocystis bettongiæ (Bourne, 1932), *Host. Bettongia lesueuri grayi* (Gould).

Acknowledgment.—The Author is indebted to Dr. H. W. Bennetts, D.V.Sc., for many valuable suggestions in the compilation of this paper.

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PLATE I.

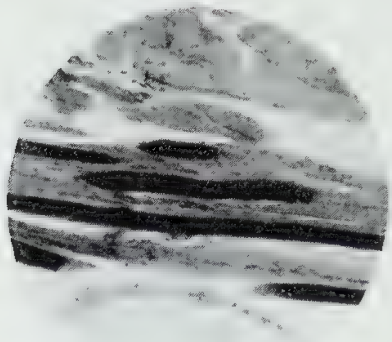
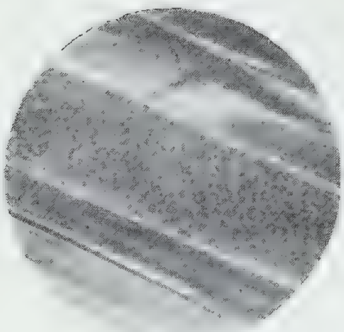


Fig. 1



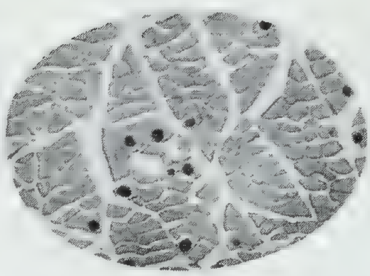


Fig. 5

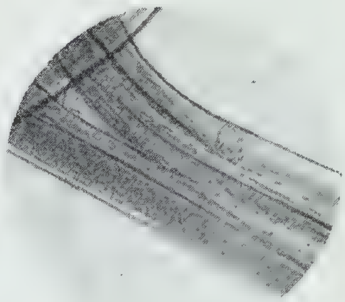


Fig. 4

Fig. 3

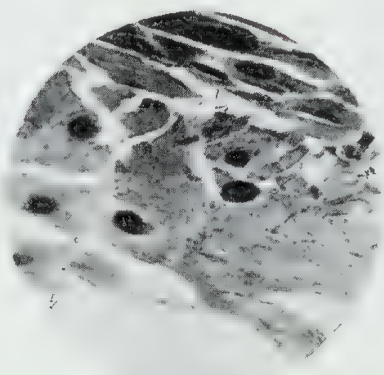


Fig. 2

Magnification: Fig. 1, 2, and 3, × 300; Fig. 4, × 600; Fig. 5, × 200.

EXPLANATION OF PLATE.

Fig. 1.—Longitudinal section of muscle of *Bettongia grayi*, showing **Sarcocystis bettongiae** Sp. n. in fibres.

Fig. 2.—Transverse section of muscle of *Bettongia grayi*, showing **Sarcocystis bettongiae** Sp. n. in fibres.

Fig. 3.—Teased muscle fibres of white mouse, showing *Sarcoystis muris* in lower fibre.

Fig. 4.—Enlarged portion of Fig. 3, showing the Sarcocyst occupying practically the entire fibre.

Fig. 5.—Transverse section of muscle of white mouse showing *Sarcocystis muris* in muscle fibres.

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Vol. XIX., 1932-33.

2.—THE ORIGIN OF THE LIQUID APPEARING FROM THE SOFT SPINES AND THE TAIL OF THE LIZARD -DIPLODACTYLUS SPINIGERUS.—GRAY.

By G. Bourne.*

Read 9th August, 1932; *Published 12th December,* 1932.

INTRODUCTION.

The lizard *Diplodactylus spinigerus* belongs to the family Geckonidæ, and is confined in its distribution to Australia. It possesses a double row of soft spines which run down the dorsal surface of the tail and extend up the back for some distance.

From these spines, and perhaps from the skin between the spines, these lizards are capable of ejecting a stream of liquid, in some cases, as far as one or two feet.

With the object of discovering whether this liquid comes from small vessels associated with the hæmolymph system or is secreted by special glands, a number of sections of the tail were examined, and it was found that the sub-epidermal layer contained dense aggregations of small vessels.

HISTOLOGY OF THE TAIL.

The tail is made up of a central piece of semi-cartilaginous tissue, surrounded by a ring of connective tissue which possesses a number of well developed fibres. External to this are several longitudinal layers of muscle fibres and investing these a thick layer of fibrous connective tissue containing muscular fibres. From this to the epidermis, a varying distance, the predominating tissue is of a loose areolar type, in which a number of small vessels ramify. Beneath the epidermis is a dense aggregation of these vessels. From this aggregation, through the epidermis to the exterior, run a number of capillaries which, however, end a short distance before the outermost epidermal layer.

The epidermis is full of pigment granules and the vessels are in most cases outlined with a similar deposit of pigment.

The spines in transverse section show a central mass of areolar tissue containing ramifying vessels, surrounded by the epidermis, into which finer branches of the areolar vessels enter, ceasing a short distance from the surface. There are no indications of either glands or gland ducts present.

Note on Synonymy.—The synonymy is that of Zietz (Rec. S. Austr. Mus. 1, No. 3 (1920), p. 185). The examination of over forty specimens shows that *D. spinigerus*, Gray, and *D. ciliaris*, Blngr., pass into one another through numerous intermediate stages, and may approach the form of *D. intermedius*, Ogilby, recorded from Day Dawn by Werner (Fauna Sudwest-Austr. 11 (1910), p 457, fig. 2). *D. strophurus* (D. & B.) does not appear to occur in Western Australia.

* Submitted in partial fulfilment for the degree of M.Sc. in the University of Western Australia.

METHOD OF EJECTION.

Considerable pressure is required to project a stream of liquid a distance of a foot or more, and an examination of the tail shows no obvious muscular mechanism which might be responsible for the process.

The small vessels in places appear to run together to form small chambers or sacs, which are shown as large black dots in the accompanying plate. It is probable that the small chambers are contractile and act as reservoirs for the material ejected; regression of the fluid back through the vessels could undoubtedly be prevented by means of valves, and the only method of escape for the contained liquid, when the small sac contracted, would be by a rupture of a small portion of the epidermis. A sudden break occurring in this way might result in the ejection.

It is unlikely that these small vesicles would be under voluntary control, and under these circumstances the innervating agent of contraction would possibly be a hormone, derived from the adrenal gland. This hormone is secreted in Mammals in times of fear or other mental or physical excitement. It possesses the ability in all Vertebrates of causing the contraction of smooth muscle in the body, and its action on these small contractile sacs can easily be realised.

The only case similar to this, known to the author, in the animal kingdom, is that mentioned by the American Zoologist, Newman,[1] who quotes the case of the horned toad, Phrynosoma, which projects a tiny stream of blood from the corner of the eye. There is probably a similar arrangement for the projection of the stream in this case, as in the case of *Diplodactylus spinigerus*, that is, a small contractile sac, possibly (in this case) a dilatation of a venule, which would place the contained fluid under pressure, rupturing would take place near the surface and a small stream of blood shot out.

DISCUSSION.

The value of this peculiar mechanism to the animal concerned is a matter for debate. Since there are no special glands in *Diplodactylus spinigerus* producing the liquid ejected it is unlikely that it would have any poisonous property, although it is known that the English hedgehog possesses lymph which has poisonous properties.

Birds commonly attempt to pick up lizards by their tails. Lizards of the Gecko group possess the ability of parting autonomously with their tails, usually leaving them in the beaks of the predating birds, and developing new ones by natural regeneration. *Diplodactylus spinigerus* parts with its tail rarely, if at all, and it is likely that the lizard has developed a new method of preserving its life. One can quite imagine that the ejection of a liquid with some force from the tail would tend to nonplus any predator attempting to catch the lizard. This appears to be the most likely explanation of the value of such a mechanism to *Diplodactylus spinigerus,* and similarly the projection of a stream of blood from the corner of the eye of Phrynosoma, would disconcert any attacking animal.

SUMMARY.

The liquid ejected from the soft spines and the skin of the Gecko, *Diplodactylus spinigerus,* is apparently derived from the hæmo-lymph system; it is probably lymphoidal in nature and is ejected from a system of sub-epidernmal lypmhatics, the liquid reaching the exterior under pressure through rupture of the epidermis.

Acknowledgment.—The Author is indebted to Mr. L. Glauert, B.A., F.G.S., Curator of the Western Australian Museum, for suggesting the undertaking of this investigation, and for supplying the synonymy of *Diplodactylus spinigerus.*

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Magnification: × 350.

Photomicrograph of portion of the tail of *Diplodactylus spinigerus,* and a section through one of the soft spines. A number of black lymphatics may be seen in the extensive sub-epidermal areolar tissue and the aggregation just beneath the epidermis is also plainly visible. A number of fine capillaries may be seen crossing the epidermis.

By Authority: Fred. Wm. Simpson, Government Printer, Perth.

3.—MINYULITE, A NEW PHOSPHATE MINERAL FROM DANDARAGAN, W.A.

By

E. S. SIMPSON, D.Sc., B.E., F.A.C.I., and

C. R. LEMESURIER, A.W.A.S.M., A.A.C.I.

(*Read 13th September,* 1932; *Published 8th May,* 1933.)

In July of this year one of the authors (E.S.S.) examined the phosphate deposits of the Dandaragan district with a view to determining their distribution and economic importance, and particularly their relation to stock breeding in the area. The district is occupied by almost horizontal beds of glauconitic and non-glauconitic sands and clay-shales, with chalk of Upper Cretaceous Age. Only one bed of chalk has been clearly defined, and at the base of this, on top of a highly glauconitic sand or clay, is a thin bed of nodular apatite, whose outcrop has been found at about a dozen points in the form of ledges projecting from gentle slopes well covered with soil.

A considerable amount of secondary chemical action has gone on in the outcrops. Decomposition of the glauconite, and possibly other associated iron compounds, has resulted in the formation of much limonite, so that the nodules are found at the surface embedded in iron-stained sand, ferruginous sandstone or hard siliceous ironstone. Some of the iron has taken the place of lime in combination with the phosphoric oxide, the common product being bright green dufrenite, which is found more or less plentifully in every outcrop. It is most strongly developed in an outcrop on Crown Grant 1110, adjacent to the Minyulo Estate and not far from Minyulo Well.*

In examining the Minyulo outcrop there was to be seen a fibrous mineral, closely resembling wavellite, which occurred in small quantities in a hard phosphatic ironstone carrying partly altered apatite nodules. Under the impression that the mineral was the comparatively common species wavellite, only a few small specimens were collected. This was unfortunate, as the mineral has been proved in the laboratory to be a well defined new species for which the authors suggest the name *Minyulite.* It is a hydrous basic phosphate of potassium and aluminium.

Occurrence.—Minyulite occurs as the complete or sometimes partial filling of minute veins and cavities in a highly phosphatic ironstone bed, which is about three or four feet thick, and whose horizontal outcrop forms the summit of a low cliff of ferruginous sandstone. The phosphatic rock is composed of a mixture of limonite, quartz grains, dufrenite, nodular apatite and glauconite grains. It represents the outcrop of a coprolite-bearing greensand-chalk contact. Immediately above it is a gentle grassy slope representing the surface of the chalk, which in turn is capped by a second bed of limonitised greensand without coprolite.

* Such wells sunk on the site of permanent springs, known to and named by the aborigines, have been important *points d'appui* for pioneers in this semi-arid country, and their positions are always shown on local maps and plans.

The matrix of the best specimens of minyulite has not been analysed, but analyses of somewhat similar material showing either none, or else only small quantities, of the new mineral, collected from other parts of the same outcrop, yielded the following results:—

Mark.	D 14.	D 18.	D 19.
P_2O_5 sol. in $2\frac{1}{2}$ E. HNO_3 ...	15·84	5·22	7·18
P_2O_5 insol. in $2\frac{1}{2}$ E. HNO_3 ...	2·67	10·92	6·29
P_2O_5 total	18·51	16·14	13·47
K_2O sol. in 10 E. HCl	3·38	·50	2·33
Na_2O sol. in 10 E. HCl	·36	1·14	·78
Fe_2O_3 sol. in 10 E. HCl	26·21	41·66	27·82
CaO sol. in 10 E. HCl	0·83	0·80	?
Siliceous insoluble	29·67	19·76	33·90

As apatite is readily soluble in warm $2\frac{1}{2}$ E.HNO_3, and minyulite slowly soluble, whilst dufrenite is practically unaffected by it, the proportions of P_2O_5 under the two headings in the table give (in reverse order) an indication of the relative proportions of P_2O_5 present in combination with iron, and not so combined.

Physical Properties.—Minyulite is distinctly crystalline, forming dense radiating groups of fine fibres, often with a silky lustre. These groups either dovetail into one another, completely filling the original cavity, or form mammillated crusts round it. In one specimen of the latter kind, the individual fibres are coarser and less coherent than in the type, and they are associated with two other colourless minerals. One of these has nearly the same Nm but is monoclinic, and more broadly prismatic. The other is only imperfectly prismatic and has a much lower Nm. On the faces of very narrow cleavages in the rock, minyulite appears as flat rosettes of radiating fibres resembling wavellite. In each case the fibres are 2 to 4 or 5 mm. long, but only a small fraction of a millimetre in diameter, usually 0.02 to 0.05 mm. No terminal planes were observed and the prism boundaries did not appear to be measurable. A prismatic cleavage is suggested.

The mineral is fragile, with a hardness of 3.5, and specific gravity 2.45, determinations on two specimens giving 2.417 and 2.453. It is colourless to milky white in colour, and is translucent in thicknesses up to 3 mm. Under the microscope, the powder (0.1 mm. or less) is colourless and transparent.

The crystallisation is proved by optical tests to be orthorhombic, the extinction being parallel to the elongation of the fibres in all positions, and a difference in the value of N being observed across the fibres as they are rolled. The elongation was proved to be negative by use of the gypsum plate, *i.e.*, $X = \frac{1}{c}$. The refractive indices determined on the type by immersion were—

Ng 1.538. Nm 1.534. Np 1.531.

On the other more coarsely fibrous specimen mentioned above, determinations gave Ng 1.538, Np 1.532, and on a third specimen Ng 1.538, Np 1.5315, in all cases with negative elongation.

Composition.—Minyulite is a hydrous basic phosphate of potassium and aluminium having the formula—

$$KAl_2(OH,F)(PO_4)_2 \cdot 3\frac{1}{2}H_2O$$

which may also be written—

$$2K(OH,F) \cdot 2Al_2O_3 \cdot 2P_2O_5 + 7H_2O.$$

An analysis was made by one of us (C.R. LeM.) on a small fraction of a gramme with the following results:—

	Per cent.	Mols.	Mol. ratios.
H_2O above 200° ...	2·79	155	1
K_2O	12·30	131 }	1
Na_2O	·45	7 }	
Al_2O_3	29·98	294	2
Fe_2O_3	trace	...	...
CaO, MgO	nil	...	...
P_2O_5	35·58	250	2
F	traces	...	...
H_2O below 200° ...	17·84	979	7
	98·94		

Chemical Properties.—The mineral is readily soluble in warm dilute NaOH and in hot concentrated HCl, and slowly soluble in warm dilute HNO_3. It dissolves in hot concentrated H_2SO_4 etching slightly a glass surface in contact with it.

On heating in a closed tube it decrepitates and yields much acid water, which etches the glass. It finally melts into opaque white globules at a dull red heat.

Specific Characters.—Minyulite possesses both chemical and physical characters which indicate specific differences between it and other related aluminium or potassium-aluminium phosphates. These are best shown in the form of a table in which the distinctive characters of minyulite are given under the headings of "Chemical Differences" and "Physical Differences."

Properties of Minyulite which distinguish it from other similar minerals

Mineral.	Formula.	Chemical Differences.	Physical Differences.
Minyulite ...	$KAl_2(OH,F)(PO_4)_2 \cdot 3\frac{1}{2}H_2O$ ...	...	...
Wavellite ...	$Al_3(OH,F)_3(PO_4)_2 \cdot 5H_2O$ ...	Presence of K, higher ratio of PO_4 to Al, less H_2O	Negative elongation, higher G, lower N. Low fusibility.
Spherite ...	$Al_5(OH)_9(PO_4)_2 \cdot 3H_2O$ ...	Presence of K, higher ratio of PO_4 to Al, less H_2O	Lower G, lower N, and biref. Low fusibility.
Vashegyite ..	$Al_4(OH)_3(PO_4)_3 \cdot 13H_2O$ ...	Presence of K, higher ratio of PO_4 to Al, less H_2O	Higher G, higher N, negative elongation. Low fusibility.
Minervite ..	$H_2KAl_2(PO_4)_3 \cdot 7H_2O$ ...	Basic not acid salt, lower ratio of PO_4 to Al, less H_2O	Higher G (no optical data).
Palmerite ...	$K_4Al_9(OH)(PO_4)_{10} \cdot 31H_2O$ ...	Lower ratio of PO_4 to K, less H_2O	Crystalline not amorphous. (No optical data).
Leucophosphite	$K_2(Fe,Al)_7(OH)_{11}(PO_4)_4 \cdot 6H_2O$	No iron, higher ratio of PO_4 to R'''	(Insufficient data for comparison.)
Taranakite ..	$KAl_5(OH)(PO_4)_5 \cdot 18H_2O$? ...	Higher ratio of K to Al and PO_4, less H_2O	Crystalline not amorphous (No optical data.)
Englishite ...	$KCa_2Al_4(OH)_5(PO_4)_4 \cdot 5H_2O$ ...	No Ca, higher ratio of K to Al and PO_4	Lower G, lower N, fibrous habit.
Millisite ..	$(Na,K)CaAl_6(OH)_9(PO_4)_4 \cdot 4H_2O$	No Na or Ca, higher ratio of PO_4 to Al and of K to Al and PO_4	Straight extinction, lower N, lower G.
Lehiite	$(Na,K)_2Ca_5Al_8(OH)_{12}(PO_4)_8 \cdot 6H_2O$	No Na or Ca, higher ratio of K to Al and PO_4, more H_2O	Straight extinction, lower N, lower G.
Wardite ...	$Na_4CaAl_{12}(OH)_{18}(PO_4)_8 \cdot 8H_2O$	No Na or Ca, higher ratio of PO_4 to Al, higher ratio R' to R'''	Or. cryst., lower N, lower G.

The type specimen is being presented to the Western Australian Museum and a paratype to the British Museum.

SUMMARY.

A complete chemical and physical description is given of a new orthorhombic phosphate of potassium and aluminium, which was found in the altered outcrops of glauconitic coprolite beds of Cretaceous age near Minyulo well at Dandaragan. The name Minyulite is proposed for it.

By Authority: FRED. WM. SIMPSON, Government Printer, Perth.

JOURNAL OF THE ROYAL SOCIETY OF WESTERN AUSTRALIA.

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4.—THE DISTRIBUTION OF THE MARSUPIALS IN WESTERN AUSTRALIA.

By L. GLAUERT.

(Communicated by permission of the Trustees of the West Australian Museum.)

Read 11th October, 1932; Published 26th June, 1933.

Since the appearance of Shortridges's "Account of the Geographical Distribution of the Marsupials and Monotremes of South-West Australia" in in 1910,* distribution maps of the Western Australian Mammalian fauna have been kept up to date, and this paper is submitted to indicate the present range of the fauna, based principally upon specimens that have reached the Museum in the last ten years.

It is unavoidable that the spread of settlement and the changes it brings in its train should have a profound effect upon the native fauna, the clearing of hundreds of thousands of acres in the wheat belt has brought about some astounding results. The animals driven from their old haunts have been forced to seek an asylum elsewhere; the tracts of poison land, the State Timber reserves, and the rougher portions of the Darling Ranges have provided a home for many, whilst others, including *Tachyglossus* and *Macrotis* (*Thalacomys*), have even attempted to establish themselves near Perth where formerly they were either extremely rare or entirely absent. *Trichosurus vulpecula* and *Dasyurus geoffroyi* are often found in the roofs of suburban residences, the former taking a toll of the garden produce; the latter paying particular attention to improperly constructed fowl runs. At least 14 species are still to be met with on the coastal plain in the vicinity of Perth.

The State of Western Australia is not a faunal unit, the South-Western corner, whilst containing a number of forms peculiar to itself, shows a marked affinity to the coastal and subcoastal districts of South-Eastern Australia: a discontinuous distribution which is considered to be due to climatic changes rather than to the foundering of extensive areas of land in the Great Australian Bight.

The boundaries of this region are not at all clearly defined. In the north it extends to Geraldton with outliers on the islands of Shark Bay, whilst on the south coast it can be traced as far east as Esperance, including the islands of Recherche Archipelago. In the north the eastern boundary is fairly close to the coast, but near Moora it sweeps inland to follow fairly closely the line of No. 3 Rabbit Proof Fence in the direction of the south coast.

Broadly speaking, the headquarters of the fauna are in the karri and jarrah forests of the south-west, although it is still dominant in the mixed "salmon gum forest and sandplain," and "savannah forests and woodlands" shown in Gardner's "Vegetation Map of Western Australia," issued by the Forests Department in 1928.

* Proceedings of the Zoological Society of London, 1908, p. 803, published April, 1910.

In the extreme north of the State the greater part of the Kimberley Division is merely a western extension of the Northern Territory, several species extending from Arnheim Land to West Kimberley in the neighbourhood of the Prince Regent River and Derby.

Of special interest is the Pilbara District, comprising much of the Pilbara and West Pilbara Goldfields, several elements of this area and of the islands off its coast have their nearest relatives in Northern Australia, *Lagorchestes conspicillatus* and *Dasyurus* (*Satanellus*) *hallucatus* being forms common to both.

The rest of the State is dominated by a fauna which is strictly Eremaean in character, *Macropus rufus* occupying the plains and *M. robustus* the hilly country. In the northern portion, at least as far south as the Warburton Ranges, *Dasycercus* is to be met with, whilst *Notoryctes* almost reaches the sea coast in the vicinity of Wollal.

When dealing with the distribution and range of species, it is often assumed that a form is more or less rigidly confined to a particular area. Whilst this may be the case in an environment where the seasons and rainfall are fairly regular, as in the South-West and the Kimberleys, it does not apply to the greater part of our Eremaea. *Macropus robustus* and *Petrogale lateralis* may remain in their particular haunts to the bitter end, but the fauna of the plains will migrate many miles to reach an area where bounteous rains have provided an ample food supply. This is well illustrated by the experience of the Museum taxidermist, Mr. O. H. Lipfert, who recently accompanied the Government party reconditioning the wells on the Canning Stock Route from Wiluna to the Sturt Creek south of the Kimberley Goldfield. On the northward journey very little animal life was met with as conditions had been bad; on the other hand, during the homeward journey, animal life, including marsupials, was astonishingly abundant, heavy rains having fallen in the interval. It has also been established that, during bad seasons, animals will become mature when their size is unusually small. The range in size of animals of similar age, judged by the state of the teeth, is at times astounding—a fact which is easily overlooked by taxonomists who are not acquainted with the conditions in the field.

LIST OF THE MARSUPIALS OF WESTERN AUSTRALIA.

DIDELPHIA.

DIDACTYLOUS SECTION.

Family DASYURIDAE.

Sub-Family DASYURINAE.

Dasyurus (*Dasyurinus*) *geoffroyi fortis*, Thos.

South-Western Australia is the headquarters of this form. It is quite common near Perth, where it breeds in King's Park and in the roofs of suburban residences.

A specimen rather paler in general colouration is in the Museum collection from Well 46, Canning Stock Route, about 20 degrees 40 south and 127 degrees east.

Apparently it does not occur in the Pilbara Goldfield, where its place is taken by *Satanellus hallucatus*.

The type locality is Arthur River, near Wagin.

Dasyurus (*Satanellus*) *hallucatus exilis*, Thos.

This is the form inhabiting the Kimberley District; a related if not identical form is known from the West Pilbara Goldfield, near Roebourne. This suggests the former extension of the Kimberley fauna to the North-West Division, which is now cut off by the advance of the arid conditions to the Ninety-mile Beach. It would appear that *D. geoffroyi* is more adaptable to the change, for it occurs as far north as 20 degrees 40 south and 127 degrees east.

The type locality is Parry's Creek, near Wyndham.

Sub-Family PHASCOGALINAE.

Phascogale (*Phascolosorex*) *apicalis*, Gray.

South-Western Australia (?) country around Albany.

This species is now probably extinct; it is not represented in the collection of the W.A. Museum.

The type locality is unknown, the specimen having been purchased of Mr. Brandt by the trustees of the British Museum.

Phascogale (*Antechinus*) *flavipes leucogaster*, Gray.

Lower South-West from Pinjarra to Cape Riche.

Said to prefer stony country. Still occurring sparsely in suitable stony or rocky surroundings throughout the area.

The type locality is Canning River, a tributary of the Swan.

Phascogale calura, Gould.

Lower South-West from Narrogin to Kojonup.

Seems to be rather rare, six specimens only having reached the Museum within the last five years.

The type locality is the Williams River in the South-West.

Phascogale penicillata penicillata, Shaw.

South-West from Fremantle to the South Coast and inland to Merredin. Far more abundant than the preceding 20 specimens received in the last five years.

Type locality presumably in New South Wales.

Phascogale penicillata pirata, Thos.

Kimberley, Napier Broome Bay, near Drysdale River, and Port George IV.

The type locality is South Alligator River in the Northern Territory.

Planigale subtilissima, Lönnberg.

West Kimberley.

Type locality, plain near Noonkambah on the Fitzroy River north of the St. George Range.

Dasycercus cristicauda, Krefft.

Eastern Division (Canning Stock Route).

One of the commonest mammals along the stock route from Wiluna to Hall's Creek, its southern limit being near Well 26. The distribution is governed by the state of the season (wet or dry).

The type locality is South Australia, probably near Lake Alexandria.

Dasycercus blythi, Waite.

Pilbara Goldfield.

Little is known about this animal. Reports received suggest that it has a fairly wide range in the North-Western Division of the State.

The type locality is Pilbara district.

Sminthopsis murina albipes, Waterhouse.

South-Western Australia, more or less coastal, but inland to Katanning, Broomehill, Gnowangerup, and Bulong, near Kalgoorlie. A very common species in the South-West.

All the specimens seen have the carpal pad on the manus transversely striated, not granular. The scaly tail is uniformly covered with short hairs, which are brownish, or brownish mixed with whitish ones above and uniformly whitish below.

Type locality Port Adelaide, South Australia.

Sminthopsis longicaudatus, Spencer.

This species does not seem to have been recorded since its original discovery, and we have no information about the type locality beyond Spencer's vague "West Australia."

Sminthopsis crassicaudata crassicaudata, Gould.

Southern part of Western Australia from Day Dawn to the South coast.

At Dongarra, and near Perth, it has at times been found on the coastal plain, although its usual western limit is the escarpment of the Darling Range.

A very common species.

The type is from the Williams River, South-Western Australia.

Sminthopsis granulipes, Troughton.

A rare form occurring here and there in the South-West of the State.

Specimens in the W.A. Museum are from Nungarin and from a locality 30 miles east of Ravensthorpe—the latter, a female, had 12 young in its pouch.

The type locality is King George's Sound, South-Western Australia.

Sminthopsis froggatti, Ramsay.

West Kimberley.

The type was found under debris near the beach in pindan scrub bordering King Sound, near Derby.

Sminthopsis larapinta, Spencer.

The Museum has specimens from "Central Australia," Alexandria, and Tanami, in the Northern Territory. The animal probably exists in East Kimberley, as Tanami is not far across the border.

The type locality is Charlotte Waters.

Sminthopsis hirtipes, Thos.

Central portion of W.A.

Specimens from Well 29 on the Canning Stock Route and Winduldarra 26 degrees 30 minutes south, 126 degrees 6 minutes east are in the collection of the W.A. Museum. The type locality is Station Point, Charlotte Waters.

Family MYRMECOBIIDAE.

Myrmecobius fasciatus, Waterhouse.

Southern portion of Western Australia from Darling Range in the west to Kalgoorlie in the east; northward to Laverton and southward to the country near Albany.

A specimen is in the W.A. Museum from Armadale, near Perth.

The clearing of the country for agriculture has affected the animal adversely.

The type locality is 90 miles south-east of the mouth of the Swan River, *i.e.,* in the vicinity of Mt. Kokeby.

Family NOTORYCTIDAE.

Notoryctes caurinus, Thos.

In sandy desert country along the Canning Stock Route and inland from Wallal.

Type locality near Wallal on the Ninety-Mile Beach, North-Western Australia.

SYNDACTYLOUS SECTION.

POLYPROTODONT GROUP.

Family PERAMELIDAE.

Isoodon obesulus, Shaw.

South-Western Australia, inland to Broomehill and Cranbrook.

Still plentiful even near Perth if environment is suitable.

The type locality is New South Wales.

Isoodon auratus, Ramsay.

Kimberley district from the Drysdale River in the north to Well 31 on the Canning Stock Route 22 degrees 30 minutes south; was once common near Broome.

The type locality is Derby on King Sound, West Kimberley.

Isoodon barrowensis, Thos.

Barrow Island, off Onslow.

Type locality, Barrow Island.

Isoodon macrouous, Gould.

Kimberley District, apparently rare.

The type locality is Port Essington, Northern Territory.

Perameles bougainvillei bougainvillei, Q. & G.

Dorre and Bernier Islands and adjacent mainland. (Onslow 9826.)

Assumed to be extinct (G. C. Shortridge), but subsequently found to be still fairly common.

Type locality, Peron Peninsula, Shark Bay.

Perameles myosura, Wagner.

South-Western Australia, near Cranbrook.

No specimens have reached the Museum since 1900. It is therefore assumed that the animal is extinct.

The type locality is Swan River.

Perameles eremiana, Spencer.

Central District, west of Warburton Ranges.

Said to be common at the time the specimen in the W.A. Museum was collected.

The type locality is in Central Australia—"Burt Plains, north of Alice Springs," and "sandhills about 40 miles north-east of Charlotte Waters," provided the specimens upon which the original description is based.

Macrotis lagotis, Reid.

Widely distributed in the State south of the Kimberley Division. The western limit seems to be the Darling Range, although the Museum has odd specimens from Perth and Upper Swan on the Coastal Plain. The animal occurs as far south as Cranbrook and Jerramungup, near the Stirling Range, and as far east as Gnawlbat, 126 degrees 15 minutes east, 26 degrees 21 minutes south. Within this extensive range the animal varies irregularly in size, cranial characters and colouration. It is not possible to distinguish satisfactory geographical races or sub-species when large series (over 40 specimens) are studied.

The type locality is "Swan River."

Choeropus ecaudatus, Ogilby.

Once abundant in parts of the interior, now seemingly on the verge of extinction in Western Australia.

No specimen in the Museum.

Mr. A. Le Souef states in a letter 2/12/1927 that he has seen a dried skin at Rawlinna. This is the only recent record known to me.

The type locality is Murray River, South Australia.

DIPROTODONT GROUP.

Family Phalangeridae.

Sub-Family Phascolarctinae.

Pseudochirus occidentalis, Thomas.

Lower South-Western Australia in small isolated colonies which suggest that the animal is on the verge of extinction through natural causes.

The type locality is King George's Sound, South-Western Australia.

Sub-Family Phalangerinae.

Dromicia (*Dromiciella*) *concinna,* Gould.

Southern portion of the State from Sandstone in the north to the South Coast. Specimens have been collected as far east as Balladonia and Bulong, near Kalgoorlie.

Still a very common species, even close to Perth.

The co-types are from "Swan River, W.A."

Petaurus (*Petaurula*) *breviceps,* Waterhouse.

Kimberley District. A single specimen (mounted) from Roebourne is in the Museum collection, but it is not at all certain that the animal was collected in that locality. It does not seem to occur there to-day, as far as can be ascertained.

The types are from New South Wales.

Wyulda squamicaudata, Alexander.

East Kimberley in mountainous country, near Turkey Creek. The animal seems to resemble *Ps. dahli* in its habits, being terrestrial, not arboreal.

The type locality is Violet Valley Station, near Turkey Creek.

Trichosurus vulpecula vulpecula, Kerr.

Southern W.A. as far north as Sholl Creek, 26 degrees south, near Lake Carnegie.

Still very plentiful in the South-West, even near Perth. At one time it inhabited all parts of the State south of the tropics where trees were to be found, but to-day its distribution is much restricted, for which both natural and human agencies are responsible.

In Western Australia the variations are such that only two satisfactory sub-species can be separated—that inhabiting the Kimberley District being characterised by certain constant features.

Trichosurus vulpecula arnhemensis, Collet.

Kimberley District, as far south as Well 43, Canning Stock Route, about 21 degrees south.

The co-types were collected at Daly River and Katherine River, Northern Territory.

Sub-Family TARSIPEDINAE.

Tarsipes spenserae, Gray.

South-Western Australia from the Irwin River south of Geraldton to the south coast as far east as Esperance.

Usually more or less coastal, but has been found along the Great Southern as far north as Wagin, and at Nyabing east of Katanning.

The animal still occurs close to Perth in suitable localities The type locality is King George's Sound, which is still the headquarters of the species.

Family Macropodidae.

Sub-Family Potoroinae.

Bettongia penicillata, Gray.

South-Western Australia, from Perth southward, is found in the coastal area as well as inland to the Great Southern and beyond.

The type of the species came from New South Wales.

Bettongia (Bettongiops) lesueuri lesueuri, Q. & G.

Dirk Hartog Island, Bernier and Dorre Islands in Shark Bay. Years ago the animal was common near Roebuck Bay (Broome), where K. Dahl obtained numerous specimens.

The type locality is Dirk Hartog Island, Shark Bay.

Bettongia (Bettongiops) lesueuri grayi, Gould.

This species, which was once very common in the interior, is now confined to the Great Southern area between Beverley in the north and Kojonup in the south. The favourite environment would seem to be supplied by "sandplain country," where burrowing is fairly easy. It is the "Kangaroo Rat" of early colonists of Swan River Colony.

The type locality is "Swan River."

Potorous gilberti, Gould.

The extreme south of South-Western Australia. Possibly extinct.

The type is from King George Sound, skulls are not uncommon in the caves of the Margaret River district, south-west of Busselton.

Potorous (Potoroops) platyops, Gould.

South-Western Australia. Possibly extinct.

The type locality is Walyema Swamps, about 40 miles N.E. of Northam; the animal is also recorded from Albany.

A single specimen from the Margaret River was sent to the London Zoological Society in 1908. This suggests that the species still exists in that area.

Sub-Family MACROPODINAE.

Lagostrophus fasciatus fasciatus, Per. & Les.

Dirk Hartog, Dorre and Bernier Islands in Shark Bay; not common.

The original specimens came from these islands and the species was not seen elsewhere by Peron and his companions.

Lagostrophus fasciatus albipilis, Gould.

South-Western Australia in a few isolated localities to the east of the Great Southern Railway; rare.

The type was collected near York by Preiss.

Lagorchestes conspicillatus conspicillatus, Gould.

Barrow Island (type locality), and formerly also on Trimouille I. of Montebello Group, north of Onslow.

Lagorchestes conspicillatus leichardti, Gould.

West Kimberley.

The original specimens were collected on Dr. Leichardt's "trip from Moreton Bay to Port Essington."

Lagorchestes hirsutus hirsutus, Gould.

Interior of the State. It has long disappeared from the York district, where the first specimens were collected by Gilbert, but survives in the desert country near the South Australian border, and along the Canning Stock Route. It is doubtful whether the island forms from Dorre and Bernier Islands are valid sub-species. Known as "Spinifex Rat" by pastoralists.

The type locality is the York district, where the animal has long disappeared.

Lagorchestes hirsutus dorreae, Thos.

Dorre Island, in Shark Bay, perhaps also on Dirk Hartog Island.

It is doubtful whether this and the succeeding sub-species can stand when compared with extensive series of the typical form from the mainland.

Lagorchestes hirsutus bernieri, Thos.

Bernier Island, Shark Bay.

Peradorcas concinna monastria, Thos.

North Kimberley, Napier Broome Bay and Drysdale River.

The type locality is Napier Broome Bay.

Petrogale lateralis, Gould.

Throughout the State, from the southern portion of the Kimberley Division in the north to the south coast in suitable localities; also on Barrow Island (specimen 2891), and Depuch Island off the coast between the Ashburton and the Yule Rivers.

Apparently now rare in the settled districts of the South-West and Wheat Belt.

The lectotype was collected by Gilbert at "Swan River." B.M. 42.5.26.3.

Petrogale hacketti, Thomas.

Recherche Archipelago, off Esperance on the South Coast. The islands upon which the animal occurs are Mondrain Island and Coombe Island, the former being the type locality.

A specimen (8614) from Lucky Bay, east of Esperance, was considered by O. Thomas to belong to this species.

Petrogale rothschildi, Thomas.

North-West of W.A. Cossack River and Nicol Bay, near Roebourne.

Apparently inhabiting a very limited area, as the common species occurs at Nullagine further east, and at Point Cloates to the south-west.

The type locality is Cossack River.

The vinous patch disappears in course of time on preserved skins, in spite of every care to exclude air and light.

Petrogale brachyotis brachyotis, Gould.

Kimberley District.

Type locality Hanover Bay.

In a letter Mr. Thomas expressed the opinion that *P. inornata*, Gld., is a synonym. See also Cat. Mars. Mon., B.M., p. 71.

Onychogalea lunata, Gould.

South-Western Australia, in isolated localities to the west of the lower Great Southern Railway, probably on the verge of extinction in the settled districts, but surviving further east towards the Great Victoria Desert.

The type specimen was collected by Gilbert at "Swan River."

Onychogalea unguifera, Gould.

West Kimberley as far south as Sturt Creek.

The type locality is Fitzroy River District, West Kimberley.

Macropus giganteus ocydromus, Gould.

South-Western Australia from Geraldton in the north to the south coast and eastward to Esperance. Odd individuals have been seen as far inland as Southern Cross. Still fairly common near Perth.

The type locality is Swan River.

Macropus giganteus melanops, Gould.

South-Western Australia. The only specimen in the Museum came from the neighbourhood of Mt. Barker.

The type locality is "Port Essington," which is obviously incorrect.

Macropus rufus occidentalis, Cahn.

This "plain kangaroo" inhabits the interior of the southern portion of the State, taking the place of *M.g. ocydromus.* Near Geraldton it approaches the coast, and to the north the boundary is indefinite. On the plains of the Gascoyne River the blue phase ♂♂ and ♀♀ are much more in evidence, suggesting that this is the type locality of Rothschild's *M. dissimulatus.*

The type locality is "Murchison River."

Macropus rufus pallidus, Schwarz.

North-West of W.A. from the Robe River in the west to the Shaw River in the east. Specimens have been obtained at the coast near Cossack. The southern limit is not known.

The type locality is Shaw River.

Macropus antilopinus, Gould.

This kangaroo has been obtained in the valley of the Negri River, East Kimberley, a specimen from that locality being in the W.A. Museum.

The type locality is Port Essington, Coburg Peninsula, Northern Territory.

Macropus robustus erubescens, Sclater.

South-Eastern part of the State north of Eucla.

The type locality is "Lake Hope, 200 miles in the interior from Port Augusta."

Macropus robustus cervinus, Thos.

"The Murchison and the Gascoyne," south to Waddouring, an inland form which does not reach the coast.

The type locality is "Pinda Station, Yalgoo."

Macropus robustus rubens, Schwarz.

North-West of the State from the valley of the Ashburton in the west to that of the Shaw River in the east .

The type locality, Box Soak, Shaw River.

Macropus robustus isabellinus, Gould.

Barrow Island, north of Onslow. The type skin was collected on Barrow Island by Captain J. L. Stokes; the animal was re-discovered by Mr. J. T. Tunney in 1900.

Macropus robustus woodwardi, Thomas.

Kimberley District extending to the extreme north and to the country near Wyndham (Parry's Creek) in the east.

The type locality is Grant Range near the Fitzroy River.*

Macropus robustus bracteator, Thos.

East Kimberley.

Type locality, McClintock Range, south-west of Hall's Creek.

Macropus (Wallabia) agilis aurescens, Schwarz.

West Kimberley, valley of the Fitzroy River. In the swamps and jungles near the river.

The co-types are from Fitzroy River and Grant Range, West Kimberley.

Macropus (Wallabia) agilis nigrescens, Lönnb.

West Kimberley, Dampier land.

The type locality is in the vicinity of Broome, where the animals were found close to the sea beach.

* *Note.*—This animal does not occur on the Murchison as stated by LeSouef and Burrell, p. 185.

Macropus (Wallabia) irma, Jourdan.

South-Western Australia, from the vicinity of Geraldton in the north to the south coast. The eastern limit is approximately the No. 3 Rabbit-proof Fence. Still common near Perth.

Macropus (Thylogale) dama, Gould.

South-Western Australia, from the Moore River in the north to the south coast (Cape Leeuwin and Cape Arid), inland to the Great Southern Railway.

The type locality is Moore River.

Macropus (Thylogale) houtmanni, Gould.

Houtman's Abrolhos, off Geraldton (East and West Wallabi Islands).

Macropus (Thylogale) derbianus, Gray.

Garden Island, off Fremantle.

Macropus (Thylogale) eugenii, Desm.

Islands in the Recherche Archipelago, off the South Coast (North Twin Peak Island and Middle Island).

The type locality is St. Peter Island, in the Nuyts Archipelago, South Australia, where the animal is now extinct.

Setonyx brachyurus, Q. & G.

South-Western Australia, from the Moore River to the South Coast; also occurs on Rottnest, Bald Island (east of Two People's Bay). Still abundant in suitable swampy localities.

The type was found dead on the sandhills at King George's Sound.

By Authority: Fred. Wm. Simpson, Government Printer, Perth.

JOURNAL OF THE ROYAL SOCIETY OF WESTERN AUSTRALIA, VOL. XIX., 1932-33.

5.—SPECIFIC NAMING OF AULOSTEGES FROM WESTERN AUSTRALIA.

By Lucy F. V. Hosking, B.A.

(*Read 11th October, 1932; Published 28th June, 1933.*)

INTRODUCTION.

Identification of new specimens of the genus *Aulosteges* from Western Australian formations has been found unsatisfactory owing to the variety of different fossils which have been described or recorded under the species *A. baracoodensis*, Eth. jun. Unfortunately the type specimen of this species is not to be found in Western Australian collections. It has therefore been thought advisable to figure the cotype with further notes on the definition of the species and its distinction from other Western Australian *Aulosteges* and also to give notes on specimens later recorded under the species *A. baracoodensis* with suggested revision of their naming.

Aulosteges baracoodensis (restricted) Eth. jun.

Pl. I., figs. 1a-c; Pl. II., figs. a & b.

1903—*A. baracoondensis*, Eth. jun., G.S.W.A. Bull. 10, p. 22, pl. II., figs. 1-2a.

The same specimens are recorded in G.S.W.A. Bull. 26, p. 55; Bull. 33, p. 12; Ann. Prog. Rept. 1901, p. 12.

Etheridge describes and figures a specimen from Baracooda Pool on the Arthur River (F178, 4760. Geol. Surv. W.A.) and mentions a specimen from the Wooramel River (F1569 Mining Museum, Sydney). Of these the type from Baracooda Pool is not to be found. The cotype has been kindly lent by the authorities of the Mining Museum.

The most noticeable character of this specimen is the shallowness of the valves. Etheridge describes the ventral valve as "more or less convex but not inflated," and his figure of the type shows a broad depressed shell differing markedly from the highly inflated subquadrate shells commonly assigned to *Productus subquadratus* which are fairly frequent in Western Australian Carboniferous rocks. Although both the Wooramel specimen and the figure of the type show a certain amount of crushing, the degree of deformation of the shell is not nearly as pronounced as it would have been had the shell been at all inflated.

The same shallow form is shown by two half specimens in the collection of the University of Western Australia (No. 10496) which are presumed to belong to the same individual and which agree well with the description of *A. baracoodensis.*

It seems therefore that this shallowness is a characteristic of the species *baracoodensis.*

Both specimens show a pronounced increase in breadth towards the anterior margin.

Etheridge's original description is as follows:—

"Sp. Char.—Shell large, rotundo-quadrate, longer than wide, concavo-convex, the convexity of low degree; cardinal margins much shorter than

the greatest width of the shell; auricles not highly developed, coincident with the curvature of the valves; cardinal angles obtusely rounded, neither quadrangular nor emarginate; lateral and ventral margins rounded, the latter faintly insinuated centrally. Ventral or pedicle valve more or less convex but not inflated, and with a faint sinus; umbonal region high, the umbo blunt and barely overturned; area high, aproximately from half to one-third the width of the cardinal margin, transversely lined but not distorted; delthyrium high and linear; deltidium very narrow, annulate but not spined or twisted. Brachial or dorsal valve concave; cardinal area linear; cardinal process small and spike-like externally; septum rather strong and showing through the test, extending for two-thirds the length of the valve. Sculpture in both valves of concentric latilaminae, thickly set with tubular spines, arising from irregularly developed low costae; spines when broken or worn leaving perforated tubercles."

The cotype does not show all these characters. The auricles are more or less displaced by crushing, but though not highly developed do not seem to be quite coincident with the curvature of the valves. The cardinal angles are scarcely "rounded" but they are obtuse angles. There is no sculpture of concentric latilaminae but concentric growth laminae are pronounced towards the margins of both valves. The area has been crushed and broken but was evidently high and extended across at least two-thirds of the width of the cardinal margins. Where the area has been broken the cardinal process is exposed. Although this is small and spike-like externally, *i.e.* on its dorsal surface, it enlarges rapidly towards the ventral surface so that at its base, near the cardinal margin, it is extremely massive and from the exposed part appears to be triangular in cross section. From this massive pyramid a narrow prong extends up into the umbo and as far as can be seen from this specimen ends in two callosities (see text, fig. 1).

Text Fig. 1.—Cardinal process of *Aulosteges baracoodensis*, side view, drawn from the cotype F1569. See also Plate I., Fig. 1c

The broken specimen in the University collection, which agrees so well with the cotype in shape and ornamentation, has the area well preserved. This is slightly lower and wider than that of Etheridge's figured type and extends for about three quarters the length of the cardinal margin. It is transversely lined. The pseudo-deltidium narrows to an acute point under the umbo. It is devoid of spines but composed of transverse laminae which under the microscope give it the "annular" appearance of Etheridge's figure 2a. The small portion of the cardinal process seen on the exterior has the spike-like appearance shown by the figure of the type and by the cotype before the matrix was removed from the areal portion. An additional feature shown by this specimen is the presence of closely set slender spines over half a centimetre in length still attached to the dorsal valve.

As the only character in which this specimen differs from the specimen and figures of *A. baracoodensis* is the slightly wider area it must be included in this species.

Measurements.	Cotype. Wooramel R.	Broken Specimen. ?Fossil Cliff Irwin R.
	mm.	mm.
Length of ventral valve	82	67
Length of dorsal valve	67	56
Length of hinge line	47	about 45
Maximum breadth	78	about 73
Height of area	about 5	3.5
Length of cardinal process beyond cardinal margin	about 9	
Depth of shell measured from flat surface held across dorsal valve	about 17	about 14
Thickness of combined valves (both specimens slightly crushed)	about 6	about 3

Summarising the characteristics of *A. baracoodensis*, these are:—

(1) broad shallow valves with maximum breadth towards the anterior margin;

(2) hinge line about two-thirds as long as greatest breadth of shell;

(3) area not extending the whole width of hinge;

(4) pseudodeltidium laminar, without spines;

(5) cardinal process very large with massive triangular part at base (this character, however, may not be restricted to this species);

(6) ornamentation of fine spines, concentric growth laminae near margins.

Aulosteges baracoodensis, var. *septentrionalis*, Eth. jun.

A series of specimens from Cape Dombey, Northern Australia, were described by Etheridge (Suppl. Parl. Paper No. 55 of 1906 South Australia p. 5) as variety *septentrionalis* of the species *A. baracoodensis*.

One of these specimens has been kindly lent to me by the Australian Museum, Sydney. It is interesting to notice that these have apparently the same shallow form as *A. baracoodensis*. They differ from it in having a flat dorsal valve, coarser and more regularly arranged spines and a cardinal process apparently without the long extension into the umbo shown by that of the cotype of *A. baracoodensis*.

REVISION OF FURTHER SPECIMENS RECORDED UNDER THE NAME A. BARACOONDENSIS.

Aulosteges sp.

Reference:—W. D. Campbell, G.S.W.A. Bull. 38, 1910, p. 52.

This specimen (F12 Geol. Surv. W.A.) is the umbonal portion of a ventral valve, very irregular due to malformation during growth. It is highly inflated at the umbo, which is strongly overturned and distorted. The area is high but almost obscured by the twisted umbo and by crushing of the shell.

The hinge margin is thickened and recurved. Altogether it shows no likeness to *A. baracoodensis*. It may be compared to *A. spinosus** which it resembles in having an open delthyrium and peculiarly upturned or "rolled" cardinal margins.

Locality: Irwin River.

Productus subquadratus and *Aulosteges* sp. cf. *A. spinosus*.

Reference:—R. Etheridge jun., G.S.W.A. Bull. 58, p. 33, pl. IV., figs. 11-13.

Two specimens are mentioned, both of which were later referred by Dr. F. Whitehouse (Austr. Assn. Adv. Sci. XVIII, 1926, p. 283 footnote) to "Taeniothaerus," an undescribed genus.

Of these two specimens No. 10929 from North of Barrabiddie is the original of Etheridge's figures 11 and 13. Apart from the ornamentation of spines it shows no characters in common with *A. baracoodensis* as it is a highly inflated shell without any pronounced widening towards the anterior margin. Etheridge says that the peculiar overturned umbo quite conceals the area. However it is doubtful whether an area is present at all. It seems advisable to refer this specimen to *Productus subquadratus*.

The second specimen, 10930, from Mt. Marmion, the original of figure 12, is also an inflated shell and has a pronounced median sinus. It may be referred to the genus *Aulosteges* as it possesses an area and the hinge margin is without teeth. The area is small with a wide triangular delthyrium closed only in its posterior third by a small pseudodeltidium. The area is very similar to that of *A. spinosus*. It was originally pointed out (Roy. Soc. W.A. XVII., p. 19) that *A. spinosus* might be the young shell of *A. ingens*. It is far more likely, however, that if *A. spinosus* represents a young form that this specimen 10930 is a mature form of the same species.

Dorsal valves of productid?

Reference:—R. Etheridge jun., in Basedow's Narrative of Exploration in North-West Australia. Roy. Geog. Soc. S.A., Vol. XVIII., p. 253.

Portions of valves of *A. baracoodensis* are recorded from the Lower horizon at Mount Marmion. One of these, F16779, a nearly complete dorsal valve, has been lent to me by the Australian Museum. This differs considerably from the dorsal valve of *A. baracoodensis* as it is almost rectangular and considerably broader than long, the broadest part being at the hinge line. The region of the cardinal process is broken away in this shell.

It does not seem possible to give even a generic name to this specimen.

UNTRACEABLE SPECIMENS.

A. baracoodensis has also been recorded from—

(a) ?28 mi. S.E. of Gascoyne Junction on the road to Dairy Creek Station. Recorded in a list in Observations on Geology and Geography of North-West and Desert Basins, F. Clapp, Proc. Linn. Soc. N.S.W., Vol. L., pt. 2, 1925, p. 55. There is no specimen at present in the collection on which this list was based, which is recognisable as *A. baracoodensis*.

* Roy. Soc. W.A., Vol. XVII., p. 17.

(b) Upper reaches of the Wooramel River between Carandibby Ranges and Bilung Pool. Recorded by A. Gibb Maitland. Summary of Geology of Western Australia, G.S.W.A. Extr. Mining Handbook, p. 36. The present location of this specimen is unknown.

OTHER SPECIES OF AULOSTEGES FOUND IN WESTERN AUSTRALIA.

Aulosteges ingens, Hosking. (Roy. Soc. W.A., Vol. XVII., 1931, p. 15).

This differs from *A. baracoodensis* chiefly in the depth of the valves contrasted with the shallowness of *A. baracoodensis;* also in the possession of a longer hinge line relative to the greatest breadth of the shell, a slightly coarser ornamentation and a pseudodeltidium which is not laminar.

Aulosteges spinosus, Hosking. (Roy. Soc. W.A., Vol. XVII., 1931, p. 17).

Only small ventral valves are known. These differ from *A. baracoodensis* mainly in having a wide delthyrium and very small pseudodeltidium and the cardinal margins "rolled." Resemblance of a larger specimen to these has already been pointed out (p. 36).

Aulosteges sp.

Pl. I., figs. 2a-b.

A collection from Luluigui Station, Kimberley Division, includes an incomplete specimen of *Aulosteges* (No. 10492 Univ. of W.A.). In inflation of the valves this specimen is similar to *A. ingens* but differs from it in having the hinge-line shorter than the greatest breadth of the shell and therefore the dorsal valve different in shape from that of *A. ingens;* a faint, low median fold on the dorsal valve; an undistorted area and a narrow, parallel-sided pseudo-deltidium bearing spines.

This specimen may be compared to one figured by Diener (Himal. Foss. Pal. Ind. Ser. XV., Vol. 1, pt. 5, p. 182, pl. VIII., figs. 13-14) as *Aulosteges* cf. *A. gigas,* Netschajew, in the following points:—depth and general outline of the shell; length of the hinge-line relative to the greatest breadth of the shell; the undistorted area; the narrow pseudo-deltidium; the faint indication of a low fold on the dorsal valve. It differs from the Himalayan specimen in ornamentation, which as far as can be seen on the Luluigui specimen consists only of coarse spines.

Another specimen (2779) from the same locality has the umbo curved over concealing the pseudodeltidium.

More specimens are necessary before further identification can be made.

ACKNOWLEDGMENTS.

I have to thank the authorities of the Mining and Australian Museums, Sydney, for the loan of specimens, also Mr. T. Blatchford, Government Geologist of Western Australia, and Mr. L. Glauert, Curator of the Western Australian Museum, for their kindness in allowing me to look over the collections of the Geological Survey and of the Museum.

Plate I.

Figs. 1a-1c—*Aulosteges baracoodensis,* Eth. jun., No. F15696 cotype. a, ventral view; b, dorsal view; c, umbonal portion showing the cardinal process after matrix was removed.

Figs. 2a-2b—*Aulosteges* sp. a, dorsal view; b, side view.


2A
2B
1B
1A
1C
Photo - H.J. Smith.

Plate II.

Figs. a-b—*Aulosteges baracoodensis*, Eth. jun. Specimen found with tray of fossils from Fossil Cliff, Irwin River. a, ventral view; b, dorsal view.

Note.—Pl. I., fig. 1b and Pl. II., fig. b, should appear concave but owing to the difficulty of photography may at first glance appear convex.

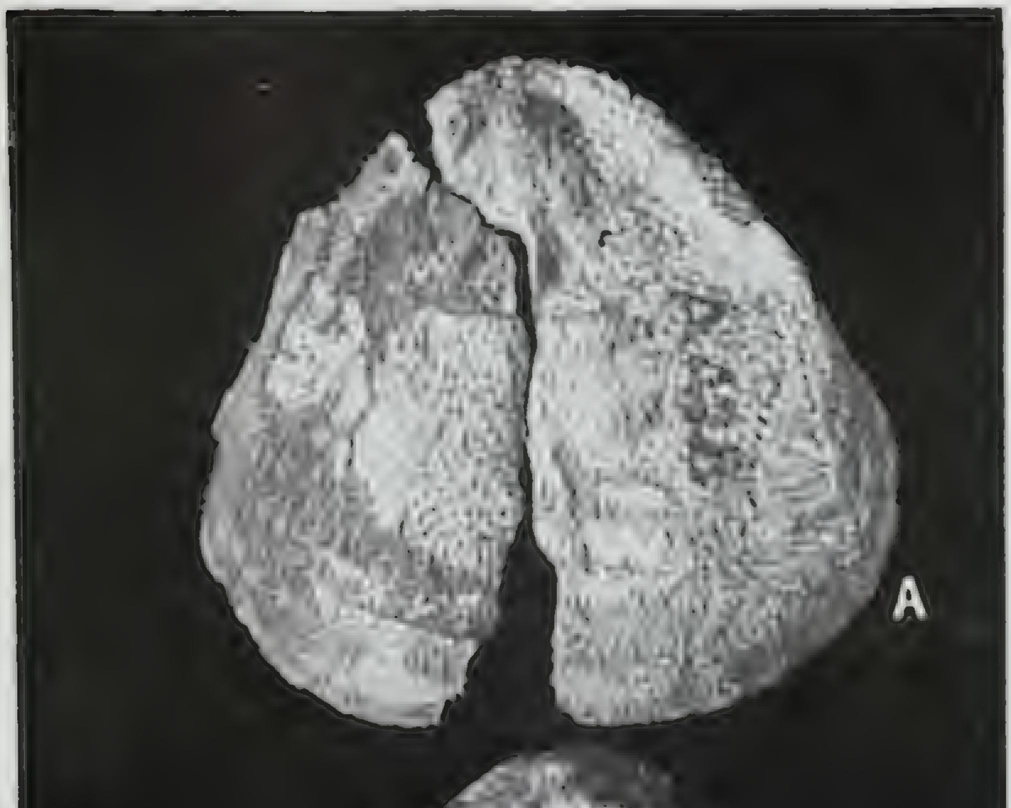

Plate II.

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6.—FOSSILS FROM THE WOORAMEL DISTRICT, SERIES TWO.

By LUCY F. V. HOSKING, B.A.

Read 13*th December*, 1932; *Published* 20*th July*, 1933.

INTRODUCTION.

Various collections made in the Wooramel River District since 1929 have yielded a number of new species, and also better specimens of those previously described (Roy. Soc., W.A., Vol. XVII., 1931).

Most of the fossils are from the "Irwin" Horizon near Callytharra Spring. They include two species of *Pustula*, both new, a true *Seminula*, two species and a new variety of *Spiriferina*, a *Linoproductus* slightly different from the typical *L. tenuistriatus* var. *foordi*, and a number of better specimens belonging to the *Productus semireticulatus* group. Of these, *Spiriferina* has not been recognised from the beds of the "Irwin" Horizon on the Irwin River, and although tiny specimens of Pustula have been found in collections from the Fossil Cliff Beds on the Irwin River, they have not been recognised as either of the species described below.

Fossils from the "*Deltopecten*" Horizon include a fine series of a new species of Diclasma, a large *Spirifer* somewhat similar to specimens from Selection Homestead, Kimberley Division, casts of *Myalina* and *Stutchburia*, and better specimens of *Cardiomorpha blatchfordi* and *Conularia warthi* which confirm previous suggestions. A specimen of *Deltopecten illawarrensis* (a species which has been previously recorded from the Gascoyne and Wyndham Rivers (G.S.W.A. Bull. 36, p. 90) found "east of Top Camp" may also come from the same horizon.

DESCRIPTIONS OF THE FOSSILS.

Genus DIELASMA, King.

(Dublin Natural History Review, Vol. VI., p. 519, 1859.)

Dielasma trigonopsis, n. sp.

Plate III., figs. 1a-c; Plate IV., figs. 1a-b and 2.

Description.—A large shell with the greatest breadth near the anterior margin which is almost a straight line so that the shell is almost an equilateral triangle with the angles bluntly rounded. The shell is punctate, thin, smooth, and ornamented only by numerous well-marked growth lines.

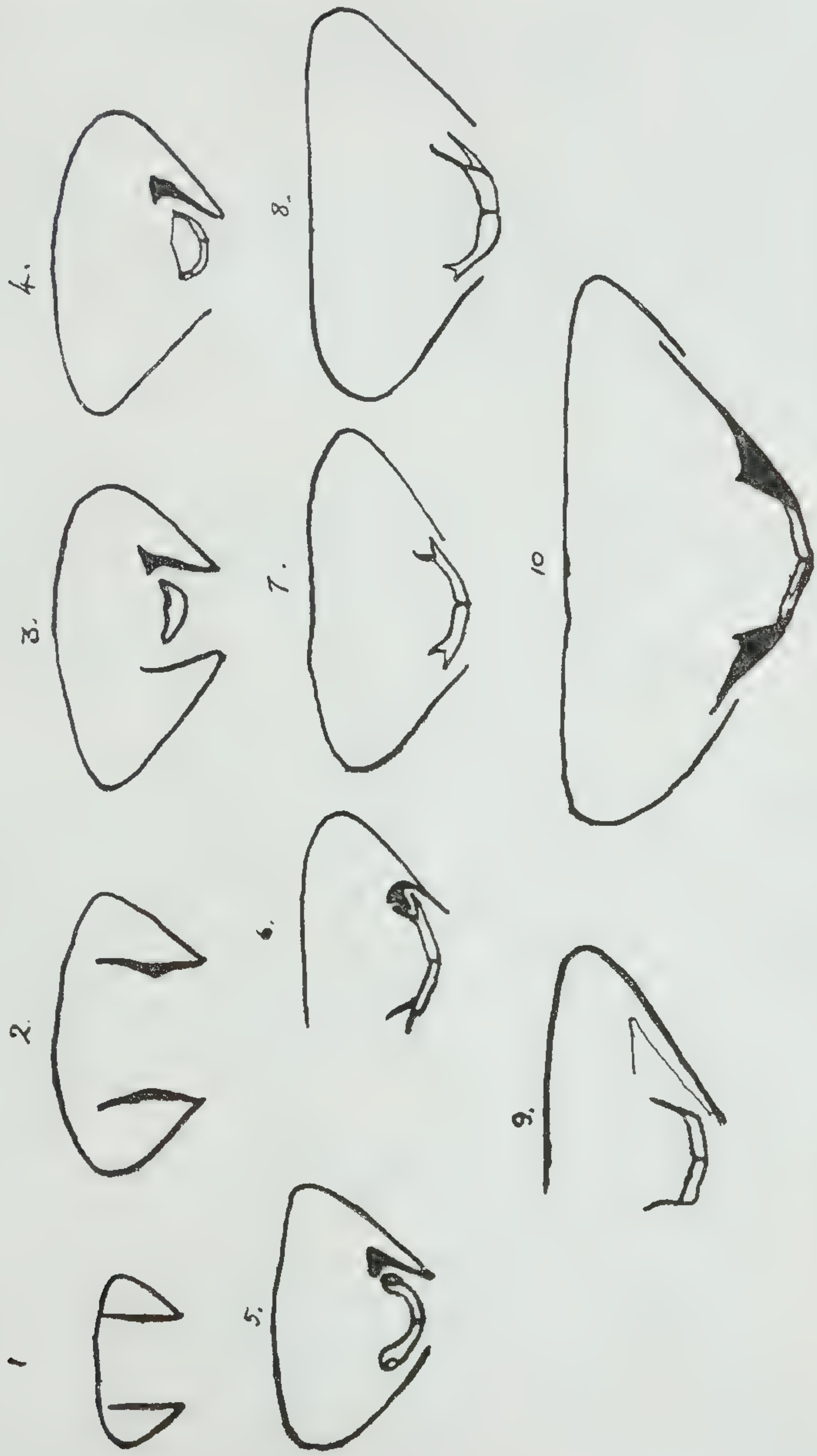
The pedicle valve is very shallow, gently curved longitudinally, flat transversely in the young shell, but at an early stage developing a broad open sinus which towards the front margin occupies the whole breadth of the shell making it concave transversely. The sinus appears at about one-third of the total length of the shell from the umbo. The foramen is very large and oblique. Its lower lip overhangs the umbo of the brachial valve. The umbonal flanks of the pedicle valve meet the ventral surface at less than a right angle, thus forming two sharp ridges diverging from the umbo separating the umbonal flanks from the main portion of the valve.

The brachial valve is almost straight longitudinally but strongly vaulted transversely, with straight sides sloping from an elevated flattened central portion. A faint sinus is present on the elevated central portion on some specimens. On one specimen the presence of this faint sinus forms two rounded ridges, one on each side, diverging from a point a short distance below the umbo.

Internal Structure.—In broken specimens crystallisation of the matrix in concentrix rings inside the shell gives a false impression of spiral brachidia which, however, are not present. In the pedicle valve there are well developed dental plates. In the brachial valve there is a concave plate between the crural lamellae extending about half the length of the valve. This plate rests on the inner surface of the valve along the median line and joins the crural lamellae a little above their bases, thus forming a pair of slender cavities converging from the general cavity of the shell towards the beak. The crural lamellae are comparatively short. The specimen sectioned had the walls of the dorsal valve broken in places, confusing the appearance of the section which did not show whether or not the crural lamellae and dental sockets had an independent origin. Sections were very similar to those of Hamburgia, Weller,* in which the two are not independent, but in Hamburgia one of the characters distinguishing the genus from Dielasma is that the concave plate is not attached along the median line as shown on this specimen. If the independent origin of the crura is not proved when fur-

* Mississippian Brachiopoda Geol. Survey, Illinois, 1914, p. 282.

ther specimens are available for sectioning, it may be necessary to erect a new genus for the reception of this species.



Text figure 1—A series of sections through the umbonal portion of *Dielasma trigonopsis*
1 and 2 pedicle valve with dental plates, 3-10 both valves.

Dimensions—

	I.	II.	III.
	mm.	mm.	mm.
Length of shell	63	73	abt. 58
Length of brachial valve	56	63	54
Greatest breadth of shell	55	73	58
Greatest thickness of combined valves ...	29	27	21
Apical angle of pedicle valve	57°	abt. 85°	...
Apical angle of brachial valve	abt. 100°	...	abt. 100°

The emended genus *Productus* is characterised by having a narrow hinge, the concentric ornamentation not prominent, a long spreading trail on the pedicle valve and a diaphragm round the anterior margin of the visceral disc. No diaphragm can be detected in the broken specimens of group (a), and specimens of both groups are excluded from the emended *Productus* by the width of the hinge, the prominence of the reticulate ornamentation, and the trail which is not "spreading."

According to the latest nomencature then, it would be necessary to erect a new genus for the Western Australian *P. semireticulatus*. More and better specimens are necessary before this multiplication of new names is justifiable.

Geological Survey Nos. $\frac{1}{4966}$ brachial valves.
$\frac{1}{4967}$ (a) and (b) pedicle valves.

Locality: Creek ½ mile west of Callytharra Spring, Wooramel River.

Genus LINOPRODUCTUS, Chao

(Productidae of China, Pt. I., Pal. Sinica, Peking, ser. B, Vol. V., fasc. 2, p. 128.)

Linoproductus cf. *L. tenuistriatus* de Vern., *var. foordi,* Eth. jun.

Plate IV., fig. 3.

These finely costate shells differ from the typical *L. tenuistriatus,* var. *foordi,* chiefly in being less ventricose and more transverse. The ribs seem to spread more on the venter, whereas in *L. tenuistriatus,* var. *foordi,* the ribs on the venter are almost parallel.

All the specimens are crushed so that it is impossible to be certain that the differences of shape, convexity, and ornamentation on better specimens would be pronounced enough to distinguish them as a separate species.

Imperfect specimens of similar less ventricose forms have been noticed in collections from a buff limestone of Holmwood, Irwin River District.

Geological Survey No. $\frac{1}{4965}$.

Locality: Creek ½ mile west of Callytharra Spring.

Genus PUSTULA, Thomas.

(Mem. Geol. Surv. Great Britain, Palaeont., Vol. I., pt. 4, p. 259, 1914.)

Pustula senticosa, n. sp.

Plate III., figs. 2-3.

Description.—Shell broad, semi-circular to subquadrate, breadth about one and a half times the length, hinge line less than greatest breadth of shell. The pedicle valve is only gently convex, not at all swollen, with about the same convexity transversely as longitudinally. The umbo is acutely pointed and incurved, sharply marked off from the ears near the hinge margin by steep slopes which flatten out abruptly further from the hinge margin. The

Remarks.—A closely similar form is *D. spatulatum*, Girty,* from the Carboniferous of North America. *D. spatulatum*, however, differs from *D. trigonopsis* in having a deeper pedicle valve, a more pronounced sinus on the brachial valve, more angular junctions of the umbonal slopes with the ventral surface, and finally in being a much smaller shell—although the description says "shell rather large" the illustration, which is apparently natural size, is only 22mm. in length.

Two forms approaching *D. trigonopsis* in size and shape are *D. nobilis*, Eth. jun.,† from near Mingenew, Western Australia, and *D. latouchei*, Diener,‡ from the Salt Range limestone of India. Both differ from *D. trigonopsis* chiefly in having a trilobate pedicle valve with a median fold or ridge.

Geological Survey Nos.:—$\frac{1}{4950}$, $\frac{1}{5232}$ and $\frac{1}{5241}$.

Localities:—

Two miles almost east of Survey Station R20, Wooramel River.

Two miles south-east of Madeline Hill, Wooramel River District.

Between Callytharra Road and No. 2 Bore Road, about five miles from Bogadi, Wooramel River District.

Genus PRODUCTUS, Sowerby.

(Min. Conchol. 1814, i., p. 153.)

The collection includes a number of specimens with the typical ornamentation of the *Productus semireticulatus* group.

Two types may be distinguished:—

(a) With the reticulate ornamentation well marked over nearly the whole of the visceral disc and extending on to the ears. These specimens are all crushed but they were evidently geniculate forms.

(b) With the reticulate ornamentation restricted to the posterior part of the visceral disc and not on the ears. This form is wider than long, with large, strongly rolled ears separated from the rest of the shell on each side by a deep groove. In this it is comparable to the genus *Marginifera*, but specimens do not show the internal shelly ridges of *Marginifera*. The pedicle valve is moderately convex with an abrupt geniculation.

Sowerby's genus *Productus* has been recently emended by H. Muir Wood,§ and a new genus *Dictyoclostus* erected which includes *P. semireticulatus* in part. The Wooramel specimens are excluded from *Dictyoclostus* by their geniculate form.

* The Guadalupian Fauna, G. H. Girty, U.S.G.S. Prof., Paper 58, 1908, p. 330, pl. xvi., figs. 3-4c.
† G.S.W.A. Bull. 27, 1907, p. 19, pl. IV., figs. 2–4, pl. VI., figs. 1–2.
‡ Himalayan Foss. Pal. Ind. Ser. XV., vol I., pt. v., p. 111.
§ H. Muir Wood, Ann. and Mag. Nat. Hist. Ser. X., Vol. V,. 1930, p. 100.

venter is low, gently sloping to the lateral and anterior margins. The ears are broad, flattened, not sharply marked off from the lateral slopes; cardinal angles obtuse. The ornamentation is of fine, erect spines emerging practically at right angles to the shell and arranged roughly in quincunx. There are about four spines in the space of three millimetres measured transversely, and three in the same space measured longitudinally. On close examination fine concentric growth lines are to be seen, particularly on the ears, but the lack of any marked concentric ornamentation is one of the chief features of the species.

The brachial valve is strongly concave and follows the contour of the pedicle valve very closely, curving in under the umbo to a remarkable degree. It shows the same ornamentation as the pedicle valve, but the spines towards the anterior margin are not perpendicular but slope radially. The concentric growth laminae are slightly more noticeable than on the pedicle valve.

The shell of both valves is very thin. This and the close association of the two valves leads one at first to suppose that only the pedicle valve is present. The internal features of the pedicle valve are unknown and those of the branchial valve only partly exposed. The cardinal process is short and very broad considering the small size of the pedicle umbo. On the ventral surface it is divided by a broad furrow into two rounded prominences, each of which bears a cup-like depression at the posterior end. Below the cardinal process is a fine thread-like median septum which extends a little over a third of the length of the shell. A brachial ridge, faintly seen, extends downwards and outwards from the base of the cardinal process in a gently sloping curve to the level of the anterior end of the mediam septum where it curves upwards again and ends at about two millimetres from the septum at about the middle of its length.

Dimensions—

	I.	II.	III.
	mm.	mm.	mm.
Length of pedicle valve	18	21	...
Breadth of pedicle valve	23	32	31
Length of brachial valve from hinge line to anterior border	15	...	...
Length of brachial valve from end of cardinal process	...	...	23
Length of hinge line	17	23	...

Remarks.—*P. senticosa* approaches nearest to *P. spinulosa*, J. Sowerby,* which has a delicate shell with an acute umbo and bears fine erect spines. *P. spinulosa,* however, differs in general shape, narrowing rapidly towards the anterior margin, has the hinge almost as long as the greatest breadth of shell and has wrinkles on the ears.

Another similar species is *P. carringtoniana*, Davidson,† which is similar in shape, and the depressed profile of the shell but differs in having a marked concentric ornamentation and fewer scattered spines.

* I. Thomas. Mem. Geol. Surv. Grt. Britain Palaeont. Vol. I. pt. 4 p. 314.

† I. Thomas loc. cit. p. 324.

The nearest Indian species having an ornamentation of fine spines is *Productus humbolti*, d'Orbigny.* This is a much more robust, convex shell with a distinct median sinus in the pedicle valve.

Geological Survey No. $\frac{1}{4970}$ (a).

Locality: Creek: ½ mile west of Callytharra Spring, Wooramel River.

Pustula micracantha, n. sp.

Plate IV., figs. 1 a and b.

Description.—Shell broader than long, semi-circular to sub-quadrangular, length of hinge almost equal to greatest breadth of shell. Cardinal angles almost right angles. Pedicle valve moderately convex. In profile the venter is gently curved but the curvature is more pronounced towards the anterior margin. In two of the three specimens there is a well-marked geniculation. The umbo is small, not overhanging, and the flanks slope gently to the lateral margins. The ears are not marked off from the umbonal flanks. The shell is ornamented with spine bases, slightly recumbent, arranged more or less in concentric rows, alternating in succeeding rows so that they are roughly in quincunx. There are about three spines in the space of three millimetres. On the ears and umbo there is a series of concentric folds which die out on the anterior portion of the shell.

The brachial valve is deeply concave with an abrupt geniculation following the contour of the pedicle valve. The ornamentation can only be seen on the ears and round the margin where there are irregular concentric folds and scattered spine bases.

The internal characters are unknown except that the median septum, seen through the shell, extends to about a third of the length of the brachial valve.

The very thin shell and the shallowness of the visceral cavity make the combined valves scarcely greater in thickness than a moderately thick pedicle valve. This shallowness may have been accentuated by compression as all the specimens show evidence of slight crushing. However, as the dorsal valve is not much broken, the amount of thickness lost by crushing must have been slight.

Dimensions:—

	I.	II.	III.
	mm.	mm.	mm.
Length of pedicle valve	14	14	13
Length of brachial valve	12	12	11
Maximum breadth	17	17	15
Length of hinge line	15	13	14
Depth of combined valves	1½	2	...

Remarks.—Thomas (p. 259) divides the genus *Pustula* into several series. Of these, *P. micracantha* belongs to series (c) containing geniculate forms

* Waagen Salt Ra. Foss. (Pal. Ind. 1884) I., IV., fasc. 4, p. 696.

such as *P. plicatilis* but differs from the members of this series in all respects other than the geniculation. The closest British forms are *P. spinulosa** and *P. carringtoniana*.† *P. micracantha* differs from *P. spinulosa* in outline, has a less pronounced umbo and less crowded spines. It agrees with *P. carringtoniana* in outline, long hinge line and ornamentation of spines, but *P. micracantha* has less marked concentric ribs and more numerous, regularly arranged spine bases.

P. micracantha differs from *P. senticosa* in being geniculate and more strongly convex, in having the umbo not definitely marked off from the lateral slopes and an ornamentation of less crowded spines with concentric folds on ears and umbo.

In general appearance *P. micracantha* is very similar to numerous members of the genus *Productella*, Hall,‡ but has not the area characteristic of this genus.

Geological Survey No. $\frac{1}{4970}$ (b).

Locality: Creek ½ mile west of Callytharra Spring, Wooramel River.

Genus SEMINULA, M'Coy (non Hall and Clarke, Schuchert, et al).

Genotype *S. pentaedra*, Phil. M'Coy Carb. Foss., Ireland, p. 150, fig. 31.)

Seminula callytharrensis, n. sp.

Plate V., 2-5.

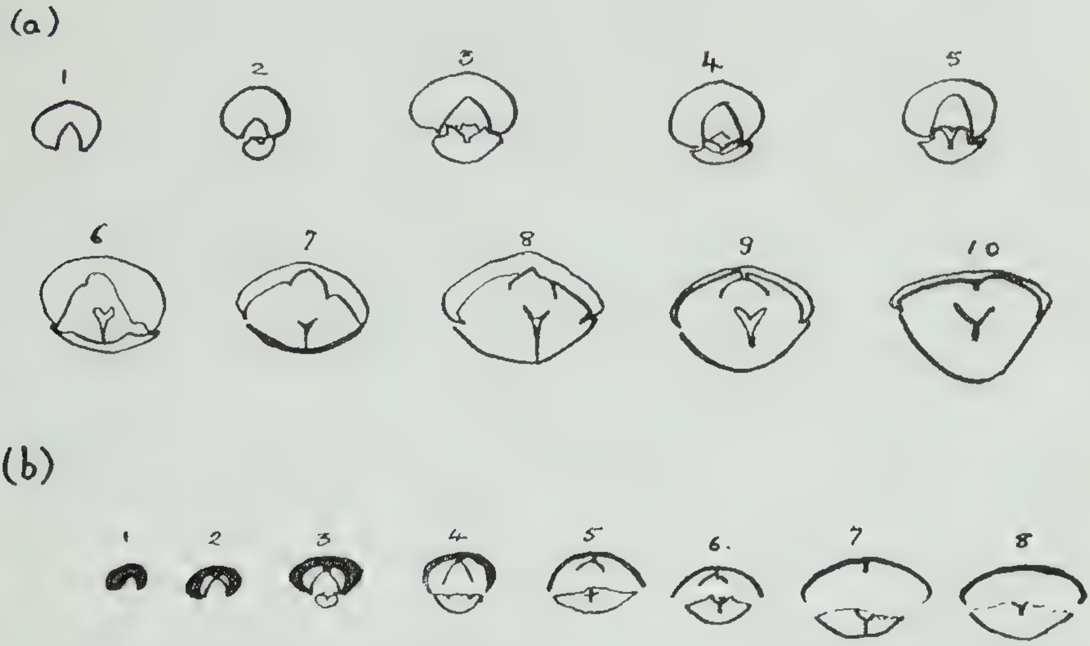
Description.—Shell circular to oval, biconvex, convexity varying. Pedicle valve has approximately the same convexity longitudinally as transversely; umbo moderately incurved with a small perforation (this is broken on several specimens, giving a false impression of a large foramen). The sinus is only seen towards the anterior margin. It may cause only a gentle wave in the margins of the valves, or if the pedicle valve is strongly produced anteriorly it may cause a pronounced insinuation of the margin without a correspondingly marked depression on the pedicle valve or fold on the brachial. Brachial valve more convex transversely than longitudinally, with no defined median fold. Surface of both valves smooth, marked with a few widely spaced growth lines, about seven, in an individual nineteen millimetres long.

Internal characters.—In the pedicle valve the dental plates are continued anteriorly into a spondylium raised above the floor of the valve on a short median septum which is continued anteriorly a short distance beyond the limit of the spondylium. In the brachial valve the hinge plate is supported on a median septum which also supports a concave cruralium. This becomes more highly elevated anteriorly. The two series of sections, (a) of a larger more convex shell, (b) of a smaller flattened circular shell, both show these characters. Although the cruralium is well shown its presence underlying (dorsal to) the hinge plate of the brachial valve, as shown in sections of *Camarophoria* by Weller (Miss. Brach., p. 169, figs. C. D. and E.) could not

* Thomas loc. cit., p. 314. † Thomas loc. cit., p. 324.

‡ Hall and Clarke Intro. to Study of Brachiopoda Rept. State Geologist of New York for 1891, 1892, p. 298.

be made out with any certainty. It appears to have been present; compare figs. (a) 3 and 4, (b) 3 and 5, with Weller, figs. C. to E.



Text figure 2—Two series of sections through the rostral portion of *S. callytharrensis.* Slightly enlarged. (a) shows internal structure of the brachial valve better than the pedicle which is much thickened; (b) shows dental plates, spondylium and septum of the pedicle valve but the internal structure of the brachial valve is obscured by the valve's being filled with crystalline calcite.

Dimensions—

	mm.
Length of pedicle valve	19
Length of brachial valve	16
Maximum breadth	18
Maximum thickness	11

Remarks.—Although it is very similar in external appearance, this species should not be confused with a species previously recorded from the Kimberley Division as *Seminula* cf. *S. subtilita,* Hall (Univ. Nos. 2507 and 2510). Those shells commonly referred to the genus *Seminula,* including Hall's *S. subtilita,* have been shown by Buckman* to belong to *Composita,* Brown, a genus of spire-bearing shells. The Kimberley specimens, which are definitely spire-bearing, are therefore *Composita* cf. *C. subtilita.*

Seminula, M'Coy, according to Buckman, is then properly applied to pentamerid genus, which includes *Camarophoria,* although this may possibly be distinguished as a sub-genus. *S. callytharrensis,* having the pentamerid internal structure closely comparable to that of *Camarophoria schlotheimi,* differs from species of this sub-genus in the total absence of plications.

The genus *Camarophorella,* Hall and Clarke, including similar non-plicate shells, was originally considered to be closely allied to *Camarophoria,* but Weller† points out that it has since been shown that the shells included in *Camarophorella* are spire-bearing.

Geological Survey No. $\frac{1}{4975}$.

Locality: Creek ½ mile west of Callytharra Spring.

* Ann. and Mag. Nat. Hist. 7th Ser. Vol. XVII., p. 324. † Miss. Brach. 1914, p. 458.

Genus SPIRIFER, J. Sowerby.

(Mineral Conchol., 1816, II., p. 41.)

Spirifer sp.

Plate V., Fig. 1.

An imperfect specimen of a large *Spirifer* is of interest as it may represent the external form of a species of which internal casts have been found at various localities in Western Australia. The main characteristic of the casts is the presence on the ventral valve of broad folds towards the anterior margin. On this specimen there are two broad folds on one side of the valve which also show on the cast where the shell is breaking away.

The specimen is possibly an old example of *S. fasciger,* Keyserling (1), as it shows the following characters:—near the umbo the ribs are grouped in bundles but these quickly become obsolete towards the anterior so that the shell has not the characteristic appearance of *S. fasciger,* but is fairly evenly ribbed except for a few broad rounded folds; the umbo is small and elevated above the hinge line giving an apical angle of about 130° on the rostral part; growth lines show that the cardinal angles were rectangular or rounded, not acute; in a few less worn parts of the shell the growth lines give some indication of the projecting laminae characteristic of *S. fasciger.*

Specimen No.: Geological Survey $\frac{1}{5231}$.

Locality: Two miles south-east of Madeline Hill.

Genus SPIRIFERINA, D'Orbigny.

(Comptes Rendus 1847 XXV., p. 268; Hall and Clarke, Pal. New York 1894 VIII., pt. 2, p. 51.)

Spiriferina cristata, Schlotheim.

Plate IV., fig. 5.

1816 *Terebratulites cristata,* Schlotheim, Beitr. Naturges. Verstein., Akad. Wissen, Munchen, t. 1, fig. 3.

For further synonmy see

1883. *Spiriferina cristata,* Waagen. Salt Ra. Foss. (Pal. Ind. Ser. XIII.), p. 499, pl. 49, figs. 3-7.

1897 „ „ Diener, Himal. Foss. I., pt. 3 (Pal. Ind. Ser. XV), p. 39, pl. 7, figs. 5-7.

1902 „ „ Dun, Records G.S.N.S.W. Vol. VII., pt. 2, p. 86, pl. XXI., figs. 15-16.

Two pedicle valves represent this species. The shell is moderately convex, breadth about one and a half times the length; hinge line equal to greatest breadth of shell, cardinal angles rounded; area triangular, concave with

(1) Reise in das Petschoraland 1843, p. 229, t. 8, f. 3. For synonmy with *S. musakheulensis* see Ethridge, Geol. Surv. W.A. Bull 10, p. 12, 1903, or Diener, Himal. Foss (Pal. Ind. Ser. XV.), 1897 1, pt. 3, p. 43 ; pt. 4, p. 35 ; 1899, pt. 2, p. 63 ; and 1903, pt. 5, p. 106.

horizontal growth lines; delthyrium wide, dental plates well developed, a median septum present. Surface of shell with four folds on each side of a deep sinus, crossed by well marked concentric growth lines. Test perforated, about four punctae to one millimetre. Where unweathered there are scattered papillae which apparently close up a series of larger perforation.

Several authors describe the area of *S. cristata* as "almost at right angles to the plane of the smaller valve." This is not so in the Wooramel specimens. Davidson, however, points out that the "disposition of the area is very variable." (Mon. Carb. Brachiopoda, p. 38.)

The Wooramel specimens differ from those from the Salt Range described by Waagen in having the area devoid of perforations.
Geological Survey No. $\frac{1}{4971}$ (a).

Locality: Creek ½ mile west of Callytharra Spring, Wooramel River.

Spiriferina cristata, Schloth. var. **decipiens,** n. var.

Plate IV., figs. 6-7.

A number of specimens of *Spiriferina* are similar to those described above, but have an ornamentation of from four to six folds on the pedicle valve and from five to seven on the brachial valve. The folds flanking the sinus on the pedicle valve are about twice the size of the next pair. The third pair where present are much smaller again. On the brachial valve the first rib on each side of the central one is about half its height. The second is much smaller and the third scarcely discernible.

There are about 4-6 perforations in the space of one millimetre. In less weathered portions of the specimens these are not apparent. Scattered tubular papillae may or may not be present. Some specimens show none, others have a few towards the anterior margin, others again show papillae over the whole surface but becoming more crowded, 2 or 3 per mm. towards the anterior margin.

These specimens differ from *S. cristata*, Schloth., only in the number of folds present on each valve, but as *S. cristata* includes forms having up to fourteen ribs, and as these forms with less than eight are characteristic of the Wooramel beds, it seems advisable to distinguish them by using a varietal name.

S. cristata, var. *decipiens,* agrees with *S. permiana,* King,* in ornamentation, but differs in the larger size of the perforations. *S. insculpta,* Phillips,† similarly has a few bold folds but differs in the more swollen character of the folds and narrower furrows, smaller beak and more closely spaced growth lines.

Geological Survey No. $\frac{1}{4971}$ (c).

Locality: Creek ½ mile west of Callytharra Spring, Wooramel River.

* King. Mon. Perm. Foss, 1850, p. 133. † Dav. Mon. Carb. Brach, 1858, p. 42.

Spiriferina papilionata, n. sp.

Plate VI., figs. 1-2.

Description.—Triangular shell, elongated transversely, hinge line forming greatest breadth of shell, cardinal angles acute and from them the lateral margins slope abruptly to the anterior border forming narrow, acutely pointed wings; shell moderately convex, umbo acute and slightly incurved over the area which is broad, concave, at first reclining at right angles to the plane of the brachial valve but curving and becoming upright under the umbo; area showing horizontal growth lines but without vertical striae. The pedicle valve is ornamented with two folds on each side of the median sinus. Of these the pair limiting the sinus are high and acute, over twice the size of the succeeding folds. There may be a third rib on each side of the wing, but this does not appear on the umbonal flanks and is only faintly visible towards the margin of the shell. The sinus is deep with the centre flattened and sharply delimited from the steep sides of the adjoining folds. The growth lines are evenly spaced, very prominent and strongly waved where they cross the folds. The shell is minutely punctate, from four to six perforations in the space of one millimetre. These perforations are not seen on the area. The surface of the valve lacks the papillae usually characteristic of the genus but this is probably due to the worn character of the specimens.

In the interior of the pedicle valve there are strong dental plates and a prominent median septum which extends over half way to the margin of the valve and projects in a high peak just below the dental plates.

A damaged specimen shows portion of a brachial valve. This has a high median fold flanked on each side by a smaller fold. On each side of this small fold the shell is narrowed abruptly to an elongated alar portion similar to the corresponding portion of the pedicle valve.

The dimensions given below are only approximate as all the specimens are damaged at the margins. The very regular growth lines, however, show that the shell must have been about twice as broad as long.

Dimensions—

	I.	II.
	mm.	mm.
Length of pedicle valve	15	17
Length of brachial valve	...	12
Breadth at hinge line	26–28	28
Depth of pedicle valve from hinge to centre of sinus ...	9	...
Height of area	5	...
Width of delthyrium at hinge...	4	...

Remarks.—*S. papilionata* agrees with *S. cristata,* Schloth., in the closely punctate structure of the test, also in the shape of the sinus quoted by Diener, pt. III., p. 42, "the bottom forming an even plane and marked off by sharp borders from the adjoining lateral portions," but it is distinguished from *S. cristata* by the sharply pointed wings, by the more acute zig-zag lines formed by the growth lines crossing the folds and by the possession of only four marked folds on the pedicle valve and three on the dorsal—those specimens of *S. cristata* having so few ribs are young forms "not exceeding 1½ lines in breadth."

Geological Survey No. $\frac{1}{4971}$ (b).

Locality: Creek ½ mile west of Callytharra Spring, Wooramel River.

Genus CARDIOMORPHA, De Koninck.

(Anim. Foss. Terr. Carb. Belg. 1842, p. 101.)

Cardiomorpha blatchfordi, Hosking.

1931 *Cardiomorpha blatchfordi*, Hosking, Royal Soc., Western Australia, Vol. XVII., p. 30, pl. VII., figs. 4 and 5.

Plate VI., fig. 3.

An incomplete specimen of the combined valves shows more of the shell of this species than the specimens originally described. The shell is comparatively thin, ornamented with concentric ridges which are finer on the anterior than on the posterior slope where there are five or six in the space of 5mm. Here they are sharp and separated by deep sulci. Where the shell is broken away the coarse concentric rugae before described are seen on the cast.

Geological Survey No. $\frac{1}{4951}$.

Locality: Two miles almost east of Survey Station R20, south bank of Wooramel River.

Genus DELTOPECTEN, Etheridge junior.

(Geol. and Pal. Queensland and New Guinea, p. 269, 1892.)

Deltopecten illawarensis, Morris.

Plate VI., fig. 4.

1845 *Pecten illawarensis*, Morris, Strezlecki's Phys. Descr. N.S.W. and Van Diemen's Land, p. 277, pl. 14, fig. 3.

1906 *Deltopecten illawarensis*, Eth. jun. and Dun, Mem. Geol. Surv. N.S.W. Palaeont. No. 5, Vol. II., pt. 1, p. 24, pl. II., figs. 2 and 3.

A single shell, remarkable for its size and its regular ornamentation of coarse ribs, is placed in the species *D. illawarensis* on the evidence of shape and ornamentation. Additional specimens showing the hinge line are necessary to determine whether the reference to the genus *Deltopecten* is correct.

The shell is apparently a right valve, equilateral excluding the ears, slightly longer from the dorsal to the ventral margin than from anterior to posterior margins, convex for over two-thirds of its length but with a pronounced flattening towards the ventral and latero-ventral margins. There are twenty-six strong, broad ribs, very regularly arranged, separated by a little over half their own width, and crossed by very close concentric laminae. The anterior ear is large, triangular with rounded outer margin, and separated from the shell by a deep byssal sinus. It is ornamented with six or seven coarse costae crossed by innumerable concentric laminae. The posterior ear is broken away.

Dimensions:—

	mm.
Dorso-ventral length	156
Antero-posterior length	150
Approximate depth of single valve ...	30
Length from umbo to anterior end of hinge	55

Remarks.—As Etheridge and Dun point out, there is some doubt about the exact characters of Morris's *D. illawarensis* as this was inadequately

described and only a portion of a valve figured. The present shell agrees well with later figures and descriptions of the species. It shows considerable likeness to *D. mitchelli*, Eth. and Dun,* but differs in being more orbicular and in the ribs being wider in proportion to the spaces between them.

Geological Survey No. $\frac{1}{5085}$.

Locality: South bank of Wooramel River. Three miles east from Top Camp.

Genus MYALINA, de Koninck.

(Descr. Anim. Foss. Terr. Carb. Belgique 1844, p. 125.)

Myalina sp.

Plate V., figs. 6 a-b.

Two casts of an inequivalve, inequilateral shell probably belong to this genus. They are obliquely elongated and compressed posteriorly. The hinge line is straight and very long, although probably less than the greatest length of the complete shell. The presence of a striated hinge plate is shown on the cast by a deep furrow which is ridged longitudinally on the side corresponding to the exterior of the hinge plate. The anterior margin is straight and falls away abruptly from the umbo. The posterior part forms the greater portion of the shell. It is produced backwards and expanded. The ventral margins of both casts are incomplete but they seem to meet the hinge line in an obtuse angle and from there to be strongly curved in almost a semi-circle, meeting the anterior margin in a gentle curve. The umbones are terminal and on the cast acutely pointed and elevated above the hinge line. The left valve is more convex than the right, which is flattened ventrally.

The generic characters of *Myalina* are the terminal umbones, the striated hingeplate and the presence of triangular septa or myophores in the beaks, which are shown in the casts as deep slits beneath the beaks. Hind (Geol. Mag. 1893, p. 514) says "all these characters are shown in King's figures Pal. Soc. Vol. III., 1849, Mon. Perm. Foss., pl. XIV., figs. 1-13." On these figures the effect of the myophores as described by Hind cannot be recognised. A prolongation between the umbones of fig. 5 is a cast of the anterior adductor, which, according to King, "lies between the horizontal plates." From this it seems that where the cast of the cavity of the anterior adductor is not preserved, as in King's fig. 12, the only effect of the plates on the cast is the abrupt deflection of the margins of the valves down to the hinge, leaving the umbo as a sharply elevated point. The abrupt gap left thus between the two pointed umbones can scarcely be described as "slits in the cast." In the absence of any figures of Myalina showing these "slits" the present casts cannot be excluded from the genus *Myalina* on the absence of myophores.

A similar genus possessing a striated hinge plate is *Naiadites*, which differs in that the umbones are only sub-terminal and a small anterior lobe is present.

In 1907 casts of a mytiliform shell from Mingenew, W.A., were described as *Myalina? mingenewensis* by Etheridge, G.S.W.A. Bull 27, p. 24, pl. 4, fig. 5, pl. 6, figs. 3-4. One of these showed a costate ornamentation. The specimens described above give no indication of the character of the external

* Eth. and Dun. Mem. Geol. Surv. N.S.W. Palaeont. No. 5, Vol. II., pt. 1, p. 11, and figs. Fletcher, Records Austr. Museum, Vol. XVII., No. 1, p. 15.

ornamentation. Otherwise *M. mingenewensis* differs from them in being slightly produced anteriorly and in having resilium furrows anterior to the umbones.

Geological Survey No. $\frac{1}{4954}$.

Locality: Two miles almost east of Survey Station R20, Wooramel River.

Genus STUTCHBURIA, Etheridge, jun.

(Records Australian Museum 1900, III., No. 7, p. 178.)

Stutchburia?

Plate V., fig. 7.

A small cast broken at the posterior margin is probably a member of this genus.

The shell is equivalve, very inequilateral, elongated; umbo subterminal, small; anterior margin rounded, narrow, shell widening posteriorly, a median sulcus present; traces of concentric ornamentation present; anterior muscle scar well marked with a very deep depression separating it from the umbonal slope; a small supplementary scar between the anterior adductor and the umbo; dorsal margins erect; hinge edentulous anteriorly but posteriorly one side of the hinge plate shows a ridge which may represent a posterior lateral tooth.

The possession of a posterior lateral but no cardinal teeth is a characteristic of the genus *Clidophorus* Hall, but as no references to this genus can be found, further comparison is impossible.

In all other characters this cast agrees with *Stutchburia.*

Geological Survey No. $\frac{1}{4957}$.

Locality: Two miles almost east of Survey Station R20, Wooramel River.

Genus CONULARIA, Miller.

Conularia warthi, Waagen.

1886 *Conularia,* cf. *irregularis* (Kon.) Waagen, Rec. Geol. Surv. India, Vol. XIX., p. 26, pl. 1, fig. 2 (non C. irregularis Koninck).

1889-91 *C. warthi,* Waagen, Salt Ra. Foss. (Pal. Ind.), Vol. IV., p. 126, pl. IV., figs. 6 a-d, pl. V., figs. 1 a-b.

1912 C. sp. nov.? cf. *C. warthi,* Glauert, Rec. W.A. Museum, Vol. I., pt. II., p. 76.

1931 *C.* cf. *C. warthi,* Hosking, R.S.W.A., Vol. XVII., p. 36, pl. XI., figs. 3-6.

A specimen recently collected from the Wooramel area shows the rhombic cross section and the ornamentation typical of *C. warthi, i.e.,* granulated ribs, very fine irregular markings extending across the spaces between the ribs and a row of intercostal tubercles on each side of the lateral furrows. This specimen confirms the identification of previous specimens from the Wooramel area which showed granulated ribs but which were not well enough preserved to show the markings between the ribs and the intercostal tubercles.

Geological Survey No. $\frac{1}{5230}$.

Locality: Two miles almost east of Survey Station R20 in cliff on south banks of Wooramel River.

Plate III.

EXPLANATION OF PLATES.

All figures are natural size unless otherwise stated.

PLATE III.

Figs. 1a-e.—**Dielasma trignopsis**, n. sp., pedicle, brachial, posterior, anterior and lateral views of specimen $\frac{1}{4950}$. The pedicle valve, which may appear convex in fig. 1b owing to an optical illusion, is shown to be concave in figs. 1c and 1d.

Figs. 2-3b.—**Pustula senticosa**, n. sp., brachial and pedicle views of two specimens. In 2b the cardinal process and part of the interior of the brachial valve are exposed where the pedicle valve is broken away.

PLATE IV.

Figs. 1-2.—**Dielasma trigonopsis**, n. sp., 1a and b brachial and pedicle views of one of the largest specimens; 2, specimen showing a slight sinus in the brachial valve dividing the elevated central portion into two rounded ridges.

Fig. 3. *Linoproductus* cf. *L. tenuistriatus*, de Vern., var. *foordi*, Eth., jun.

Fig. 4.—**Pustula micracantha**, n. sp., pedicle and brachial views of the combined valves.

Fig. 5.—*Spiriferina cristata*, Schlotheim, pedicle valve.

Figs. 6-7.—*Spiriferina cristata*, Schloth, var. **decipiens**, n. var., fig. 6 pedicle valve, fig. 7 brachial valve.

Plate IV.

PLATE V.

Fig. 1.—*Spirifer* sp.

Figs. 2-5.—**Seminula callytharrensis,** n. sp., 2a-e pedicle, brachial, lateral, posterior and anterior views of the same specimen. Fig. 2a is very slightly enlarged; 3, pedicle valve showing spondylium and fine perforation at apex, the large hole shown in the umbo in Fig. 2b is due to breaking of the specimen; 4 and 5, anterior views of the two sectioned specimens (see text fig. 2) showing variation in convexity and in the size of the sinus.

Figs. 6a-b.—*Myalina* sp.

Fig. 7.—*Stutchburia* sp.

Plate V.

PLATE VI.

Figs. 1 and 2.—**Spiriferina papilionata,** n. sp., 1a-d pedicle, posterior, lateral, and interior views of one specimen; 2, brachial view of combined valves.

Fig. 3.—*Cardiomorpha blatchfordi,* Hosking, showing portion of shell. The other side of this specimen (1/4951) shows the coarse rugae and is identical with specimens previously described.

Fig. 4.—*Deltopecten i lawarrensis,* Morris ($\frac{19}{26}$th natural size).

Plate VI.

ACKNOWLEDGMENTS.

I have to thank Mr. T. Blatchford, Government Geologist, Colonel Nicholson, of the Wooramel Oil Syndicate, and Mr. R. A. Hobson for the opportunity of examining these specimens, also Mr. H. G. Smith, of the Department of Geology of the University of Western Australia, for the preparation of the photographs from very unpromising material.

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7.—DISTRIBUTION OF DEVONIAN ROCKS IN THE KIMBERLEY DIVISION;

and

DESCRIPTION OF A RECENT COLLECTION OF DEVONIAN FOSSILS FROM THE KIMBERLEY DIVISION.

By LUCY F. V. HOSKING, B.A.

(*Read 13th September*, 1932; *Published 14th August*, 1933.)

DISTRIBUTION OF DEVONIAN ROCKS IN THE KIMBERLEY DIVISION.

A study of collections of fossils from the Kimberley Division shows that Devonian rocks have a wider distribution than has been supposed. Fossils of definitely Devonian age have been found at a number of localities, most of which lie in the area between the Margaret River and Christmas Creek. These localities are:—

(1) Minyu Gap, Rough Range (long. 135° 31′, lat. 18° 25′). Here the rock is a white crystalline limestone containing such characteristic Devonian forms as *Atrypa aspera, A. desquamata, A. reticularis, Schizophoria striatula, Wilsonia cuboides* and *Pugnax pugnus* (see pp. 71-75).

(2) One mile south of Mt. Pierre Gorge and six miles S.W. of Trig. station J.8 (Mt. Pierre Gorge is not at Mt. Pierre but about twenty-seven miles to the south-east).

Specimens from this locality, Nos. 2523-2528 in the collection of the University Department of Geology, include *Atrypa aspera* and *A. desquamata* (see pp. 71 and 72) in a white or cream-coloured limestone matrix and crinoid stems in a reddish limestone, also a much weathered median section of a cephalopod similar to sections of cephalopods from Mt. Pierre.

(3) a. Mt. Pierre.

From here Foord (1, p. 149) records *Atrypa reticularis, Rhynchonella cuboides, R. pugnus, Spirifera, Orthoceras* and *Goniatites*. These specimens are in the Western Australian Museum. The *Atrypa* specimens (Geol. Surv. No. 10005) are two pieces of white limestone, one of which shows the impression of *Atrypa aspera*, the other contains a specimen of *A. desquamata*. The specimens of *Rhynchonella* (10007) are also in a white limestone matrix. The *Orthoceras* and *goniatites* as well as specimens in the University collection (3028-3030) from the same locality of crinoid stems, *Orthoceras* and various goniatites, are in a reddish limestone matrix.

(3) b Mt. Pierre Creek on track from Fitzroy Crossing to Hall's Creek (near Mt. Pierre).

A large suite of specimens from this locality collected by Professor Clarke and Messrs. Talbot and Blatchford in 1927 is in the collection of the University. The specimens include crinoid stems, a single specimen of a solitary coral, *Orthoceras* and several types of goniatite all in slabs of red limestone.

(4) Minnie Pool (about long. 126° 2′, lat. 18° 23′ S.).

R. L. Jack (2, p. 11) records Etheridge's determination of stromatoporoids from the limestones of Minnie Pool which "are therefore either Silurian or Devonian, certainly not Carboniferous.'" The specimens are described by Etheridge (3, p. 258 and 260) as *Actinostroma subclathratum* and *Stachyodes dendroidea*.

(5) "Opposite Mt. Krauss."

In Hardman's Second Report on the Geology of the Kimberley District 1885, p. 17, he says—"In several places in Rough Range, at Mt. Pierre, at Mt. Krauss, to the south of the Hull Range and in the rocks opposite to that hill* on the south side of the Margaret River, quantities of fossils of Carboniferous age were obtained including Sponges (*Stromatopora*) . . ." The stromatoporoids *Actinostroma clathratum* and *Stromatoporella eifeliensis* were described by Nicholson (1, p. 193) who comments on the presence of such typical examples of these European Middle Devonian species in rocks of the Kimberley District of Western Australia.

The corals *Cyathophyllum virgatum, C. depressum, Pachypora tumida* and *Aulopora repens* from the same locality are described by Hinde (1, pp. 194-199), who ascribes them doubtfully to the Devonian.

Both the stromatoporoids and several of the corals are also recorded from the Rough Range but the exact locality is unknown.†

(6) Barker Gorge, Napier Range.

A collection from this locality made by H. P. Woodward in 1906 is described by L. Glauert (4, p. 111). The specimens, which are all in a red limestone matrix, include crinoid stems, *Phillipsastraea, Pachypora, Rhynchonella* cf. *timorensis, Proetus* sp. and a portion of a Coccostean fish. The last-named places the age definitely as Devonian. A goniatite is listed but this specimen (F. 332, 6927) is only a broken fragment scarcely recognisable as a cephalopod.

Notes on Basedow's collection contain a reference (3, p. 257) to a white crystalline limestone containing crinoid stems and brachiopods from the Barker Gorge. A later collection was made in 1922 by Mr. J. E. Wells. The specimens (W.A. Museum, Nos.

* Evidently Mt. Krauss.

† It seems that the locality note given by Nicholson, "Rough Range, opposite Mt. Krauss," has been taken to mean one locality, *i.e.*, a spot in the Rough Range opposite Mt. Krauss, but from Hardman's Report it is evident that *two* of the localities at which fossils were collected were: (*a*) an unknown locality in the Rough Ranges, (*b*) the rocks opposite Mt. Krauss on the South side of the Margaret River.

4412-4443) include a stromatoporoid, *Phillipsastraea, Atrypa, Schizophoria striatula, Pugnax pugnus, Wilsonia cuboides, Spirifer* cf. *disjunctus, Euomphalus, Bellerophon* and *Orthoceras.* They are in red and red and white limestone.

(7) Napier Downs, Napier Range (long. 124° 35′, lat. 17° 8′ S.).

The presence of *Stromatoporella* in a white limestone from Napier Downs, according to Etheridge (3, p. 257) "will relegate this limestone to a rather low position in the stratigraphical sequence." The specimen which is described as *S. Kimberleyensis* (p. 259) is very similar in structure to *S. eifeliensis,* characteristic of the Middle Devonian of Europe.

At Mt. Pierre, 3a above, the red limestone containing goniatites is known to underlie the Lower Carboniferous limestone of the Rough Range (5, p. 13, 6, p. 22), thus corresponding to the position of the Devonian limestone of the Barker Gorge, at the base of the limestones forming the Napier Range (4, p. 112) which are also considered to be of Lower Carboniferous age.

The localities (2) and (3) lie on the crests of anticlines, of which that at Mt. Pierre is mentioned by Wade (5, p. 21) and that at Mt. Pierre Gorge is shown on maps by H. W. B. Talbot accompanying reports by Wade (5) and Blatchford (6). A line drawn from Mt. Pierre Gorge along the line of strike passes very close to Minyu Gap, which may therefore lie on the same anticlinal axis.

It seems likely that Devonian rocks may be found emerging from the overlying Carboniferous wherever anticlines of a post-Carboniferous folding have been denuded exposing the lower strata.

Age of Fossiliferous Horizons.

Haug, Traité de Géologie, p. 711, referring to the Kimberley Division, says that the presence of the Middle Devonian is proved by the stromatoporoids (*Actinostroma clathratum* and *Stromatoporella eifeliensis*), that of the Upper Devonian by *Rhynchonella cuboides* and *Rhynchonella pugnus* associated with indeterminate goniatites.

Benson, who gives a list (7, p. 20) of the Devonian fossils from the Kimberley Division recorded before 1922, states "The accounts of the field occurrence do not indicate that there are two fossiliferous horizons as Haug assumes, and we must therefore consider the Kimberley limestone to be of late Givetian or more probably Frasnian (early Upper Devonian) age."

Although accounts of field occurrence do not indicate that there *are* two fossiliferous horizons, equally they do not indicate that different horizons *are not* present. Considering the very small amount of field work that has been done in the Kimberley Division, one can scarcely expect such detailed information.

The constant difference of the matrix of brachiopods from that of cephalopods shown by the large numbers of fossil and rock specimens examined from localities (1)-(3)b seems to indicate that, in the Margaret River-Christmas Creek area at least, there are two bands of limestone distinguishable: (a) the white or cream-coloured Atrypa limestone with numerous

brachiopods, (b) the reddish goniatite limestone with Orthoceras and crinoid stems but no brachiopods—

(a) The *Atrypa* limestone contains *Pugnax pugnus* and *Wilsonia cuboides;* therefore, according to Haug, Traité de Géologie, p. 711, is Upper Devonian, although these brachiopods may extend down into Middle Devonian.

(b) The red goniatite limestone, from its position below the Lower Carboniferous limestones of the Napier and Rough Ranges, has long been assumed to be Devonian. The goniatites, which should afford reliable evidence of the age of this limestone, have not been sufficiently studied. Foord (1, p. 102) compared a few fragmentary specimens to *G. rotatorius,* a basal Carboniferous form. Chapman (8, p. 7) tentatively lists several genera as "*Aganides?* sp. nov.; cf. *Gonioclymenia* sp.; *Gastrioceras* sp.

The assumed Devonian age of these goniatite beds is perhaps confirmed by their occurrence at the same localities, viz., Mt. Pierre and Mt. Pierre Gorge, as the Atrypa limestone although, indeed, no details of the field relationships between the two are known.

The examination of collections from Barker Gorge does not show a similar twofold division. Here the red limestone, undoubtedly Devonian, contains Atrypa and other brachiopods. There is one piece of a slightly different looking red limestone containing *Orthoceras,* but there is no information as to whether or not this comes from the same horizon as the brachiopods. Apart from one very poor specimen, referred to previously, goniatites such as those so plentiful at Mt. Pierre, have not been found. There is a single specimen of a stromatoporoid.

The presence of the Middle Devonian horizon referred to by Haug, cannot be definitely proved owing to the uncertainty of the locality, "opposite Mt. Krauss," from which the two stromatoporoids are recorded. Crusts of what is evidently a stromatoporoid occur on weathered specimens of both the *Atrypa* limestone from Gogo Station and the Goniatite limestone from Mt. Pierre.

The record of stromatoporoids from Prince's Springs, Rough Range (8, p. 6), and of *Stromatoporella kimberleyensis* from Napier Downs (3, p. 259) raises the question of the age of the massive limestones forming the Napier, Oscar, Geikie and Rough Ranges, which have been regarded as Lower Carboniferous. Convincing palaeontological evidence for this is lacking. Although lists of possibly Carboniferous fossils are given by Hardman (9, pp. 10 and 17), there are no specimens of these in the various collections. Amongst those recorded by Wade (5, p. 19) and Blatchford (6, p. 18), Lonsdaleia alone indicates a definitely Carboniferous age, yet amongst those recorded from Prince's Springs are three Devonian genera, *Alveolites, Pachypora,* and *Stromatoporella.* The only definite indication of the age of these limestones is that they are known to overlie the Devonian limestones of Mt. Pierre and the Barker Gorge apparently without unconformity (5, p. 9).

DEVONIAN FOSSILS FROM THE KIMBERLEY DIVISION.

A white crystalline limestone collected in 1929 by Messrs. T. Blatchford and H. W. B. Talbot from Minyu Gap, Rough Range (long. 135° 31′, lat. 18° 25′), has yielded a small suite of typical Devonian fossils. A few specimens of the same species collected in 1927 from Gogo Bullock Paddock (in which Minyu Gap lies) are in the collection of the University of Western Australia.

Five brachiopod genera are represented, but by far the most abundant in the limestone are specimens of *Atrypa*. These form a very variable series, varying from finely ribbed to coarsely ribbed, and from flattened to deeply convex shells. They fall into three groups according to their ornamentation: (1) Those with coarse ribbing, which may be included in the species *A. aspera*, Schloth; (2) those with fine ribbing, which may be included in the species *A. desquamata;* and (3) an intermediate group linking those of group (1) with those of group (2).

Atrypa aspera, Schloth.

(Pl. VII., figs. 1a-c and 2.)

The coarsely ribbed forms which may be referred to this species resemble forms from Chitral (10, p. 55, pl. III., figs. 4 7) and Burma (11, p. 99, pl. XV., figs. 10 and 10a), rather than those from England (12, p. 57, pl. X., figs. 5-8, and 13, p. 118).

The typical *A. aspera* has the umbo of the ventral valve incurved. This is not shown on the Western Australian specimens. The smaller ones show a small sharp umbo with a subterminal foramen. One or two of the larger ones show the umbo very slightly turned over, but most of the larger specimens are too imperfect in the region of the umbo for this criterion to be determined.

The specimens vary in size from 10mm. to 26mm. in length. In smaller specimens the breadth equals the length, in larger specimens the breadth varies from equal to, to one and a quarter times the length. The young shell is more or less flattened. Larger shells vary from shallow biconvex shapes to those in which the dorsal valve is deeply convex. In some of the flattened forms there is no sinus. A gentle sinus may be present at the anterior margin only. One or two more convex shells have the anterior margin of the ventral valve produced forward. There is no dorsal fold.

As pointed out by Reed, the coarseness of the ribbing varies so that there is great difficulty in placing a line of demarcation between *A. aspera* and *A. reticularis.*

Dimensions—	I.	II.	III.
	Largest Specimen.	Average-sized	Specimens.
Length of ventral valve ...	25mm	21mm.	20mm.
Breadth	33mm.	25mm	20mm.
Thickness	14·5mm	12mm.	10mm.

Specimen numbers:—Geological Survey $\frac{1}{5207}$.

Dept. of Geology University 10,033

Atrypa cf. A. aspera.

A single specimen, $\frac{1}{5208}$, with the coarse ornamentation of *A. aspera,* is rather more convex than the average specimens and has a more pronounced sinus at the anterior margin. The lateral margins of the ventral valve are bent ventrally so that the lateral portions of the valve are concave.

This is possibly only an extreme variant of the more convex form of *A. aspera,* but at present the collection does not contain examples linking it to them.

Atrypa desquamata, Sowerby.

(Pl. VII., figs. 3a-c and 4a and b.)

The shells with finer ornamentation agree well with descriptions and figures of *A. desquamata* (12, p. 58, and 11, p. 98). They are circular to transversely oval in shape, the larger shells moderately convex but not as ventricose as *A. reticularis.* A slight flattening of the ventral valve near the margin causes a slight sinus on the larger specimens. The median depression in the dorsal valve mentioned by Whidborne (13, p. 117) is not present in well preserved specimens. In many exfoliated specimens there is a shallow groove running from near the umbo to the anterior. This is due to the uncovering of the depression on the cast caused by the medio-longitudinal ridge on the interior of the shell. The umbo of the ventral valve is erect and produced beyond the dorsal valve. This is one of the main points distinguishing the species from *A. reticularis* in which the umbo is incurved. A single specimen, 10032, of the dorsal valve from which the ventral valve has been weathered, shows in the calcite filled interior the bases of the spires, cf. Davidson, fig. 7, pl. XI.

Dimensions—	I.	II.	III.
Length of ventral valve ...	26mm.	20mm.	14mm.
Length of dorsal valve ...	25mm.	19mm.	12mm.
Breadth	28mm.	21mm.	14mm.
Thickness	15mm.	12mm.	7mm.
Length of hinge (approx.)	13mm.	...	7mm.

The Western Australian specimens like those from Burma described by Reed (11, p. 98, pl. XV., figs. 8-9a) show few of the discriminatory features mentioned by Whidborne (13, p. 115 and 116). They vary in convexity and apart from the sharpness of the umbo which is seldom well preserved, there is little to distinguish the more convex forms of *A. desquamata* from the less convex forms of *A. reticularis.*

A. desquamata has been recorded from the Fanning River district in Queensland (14, p. 66) and from the Murrumbidgee beds of New South Wales.*

The Western Australian specimens seem rather similar to those from Queensland as they agree well with Etheridge's remarks "very much more transverse than those represented by Dr. Davidson on pl. X. of his Devonian monograph but not more so than some of his figures of pl. XI. of the same work. Again the relative convexity of the valves—is very much less than Dr. Davidson's fig. 1b of pl. XI., but is a little more pronounced than the fig. 3a of the same plate."

Specimen numbers—Geological Survey $\frac{1}{5209}$.

Dept. of Geology, University 10032.

* Sussmilch in his Geology of New South Wales lists this on p. 63 as from the Murrumbidgee beds. De Koninck (15 p. 78) records *A. desquamata* but gives no locality.

Atrypa sp. (group 3).

(Pl. VII., fig. 5.)

A number of specimens show ribbing intermediate between that of *A. aspera* and *A. desquamata.* They are all more convex than the average specimens of either of these species and differ from *A. reticularis* in having a sharply pointed umbo.

At present it seems impossible to give these a specific name.

Specimen numbers—Geology Survey $\frac{1}{5210}$.

Atrypa reticularis, Linné.

Three specimens may be placed in this species. Two are elongately oval specimens which compare closely with Davidson's pl. X., Fig. 3 (12). They have slightly finer ornamentation than the specimens grouped as *A. desquamata,* are slightly more convex and have the anterior margin of the ventral valve prolonged, giving a more pronounced sinus at the margin. The umbo is only moderately incurved. The third specimen is large with ornamentation similar to the specimens of *A. desquamata* but a much more swollen dorsal valve. The umbo of the ventral valve is incomplete but the dorsal valve is so swollen in this region that it overshadows the ventral and no deltidium is visible. Even were the tip of the umbo present it could have only projected a fraction above the dorsal valve.

This specimen has a portion of the lamelliform expansion of the shell still attached.

Specimen numbers—Geology Survey $\frac{1}{5211}$.
Dept. of Geology, University 10031.

Atrypa casts.

There are numbers of casts in the collection. On the dorsal surface of five of the smaller ones, $\frac{1}{5213}$, the median depression is very pronounced and bounded on each side by a slight ridge. It is impossible to say whether or not this is a characteristic of a separate species.

Schizophoria striatula, Schloth.

(Pl. VII., fig. 6.)

Although there are only four specimens and in none of these is the area completely exposed, the general features of the specimens are so like those of *S. striatula* that no hesitation is felt in identifying them with this species. They agree with Davidson's description (12, p. 88, pl. XVII., figs. 4-7) in having a transversely oval shell, the dorsal valve much more convex than the ventral, particularly near the umbo, ventral valve with a broad sinus near the front margin, area of the ventral valve wide, that of the dorsal narrow, ornamentation of fine radiating striae. The striae do not appear to "augment in thickness and prominence producing small, hollow, threadlike, tubular spines" but without better specimens it would be impossible to say definitely that these were absent.

Spirifer sp.

(Pl. VII., fig. 7.)

A single specimen of a small *Spirifer* is possibly a new species. It seems likely from its size that it is a young form so that until further specimens are available it would be useless to define a species.

The valves are evenly convex, curved at the anterior margins so that, meeting, these form a blunt edge. Both valves are ornamented with simple strong, rounded ribs, about sixteen on the ventral valve and seventeen on the dorsal. The sinus of the ventral valve is bounded on each side by a strong rib. A single finer rib lies in the sinus. There is no fold on the dorsal valve but its position is occupied by two stronger ribs which will evidently form the fold in a larger shell. The umbo of the ventral valve is high and acute. There is a broad concave area with a wide delthyrium.

Dimensions—

Length of ventral valve	10mm.
,, dorsal valve	8mm.
Breadth, max. at hinge line	12mm.
Thickness	8mm.
Height of area	3mm.

Specimen Number—

Geology Survey $\frac{1}{5218}$.

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Spines are not shown in figures of specimens from Burma (11, pl. XIII., figs. 19-21), which show a few widely spaced concentric growth lines as do the Western Australian specimens. Figure 21 is very closely comparable to one of these specimens.

Dimensions

Length	18mm.
Breadth	21mm.
Thickness	13mm.

Specimen Numbers—

Geological Survey $\frac{1}{5214}$.

Wilsonia cuboides, Sowerby.

The collection contains a single specimen and a fragment, both showing the fine ribbing and abrupt parallel-sided sinus of *W. cuboides*. The specimen is very similar to one figured by Davidson (12, p. 65, pl. XIII., fig. 16). It is not well enough preserved to show whether the ribs are split or grooved near the margin.

A specimen of *W. cuboides*, marked △ 8, Geo. Surv. No. 10008, from the Rough Range is recorded by Foord (1, p. 102). On this specimen grooves are discernible on two of the ribs.

Specimen Number -

Geological Survey $\frac{1}{5216}$.

Pugnax pugnus, Martin.

There are a number of specimens of this species (12, p. 63, and plates and 16, p. 97) varying from flattened to tumid shells with a pronounced fold and sinus. Ribs are obsolete on the posterior part of the shell. The generic name was confirmed from the internal structure shown by grinding down the umbo of one of the specimens.

Foord records tumid and flattened varieties of *Rhynchonella pugnus* from Mt. Pierre (1, p. 101). Sections of one of these specimens (△ 7, Geol. Surv. 10007) were also ground and showed very clearly the dental lamellae of the ventral valve, the divided hinge plate of the dorsal valve and the lack of median septum and cardinal process, all characters of the genus *Pugnax* (17, p. 202).

1 2. 3. 3a. 4

Series of sections through the umbo of *Pugnax pugnus*, specimen 10007, natural size except 3a, which is 3 slightly enlarged.

Specimen numbers—

Geological Survey $\frac{1}{5217}$
Dept. of Geology, University 10,034.

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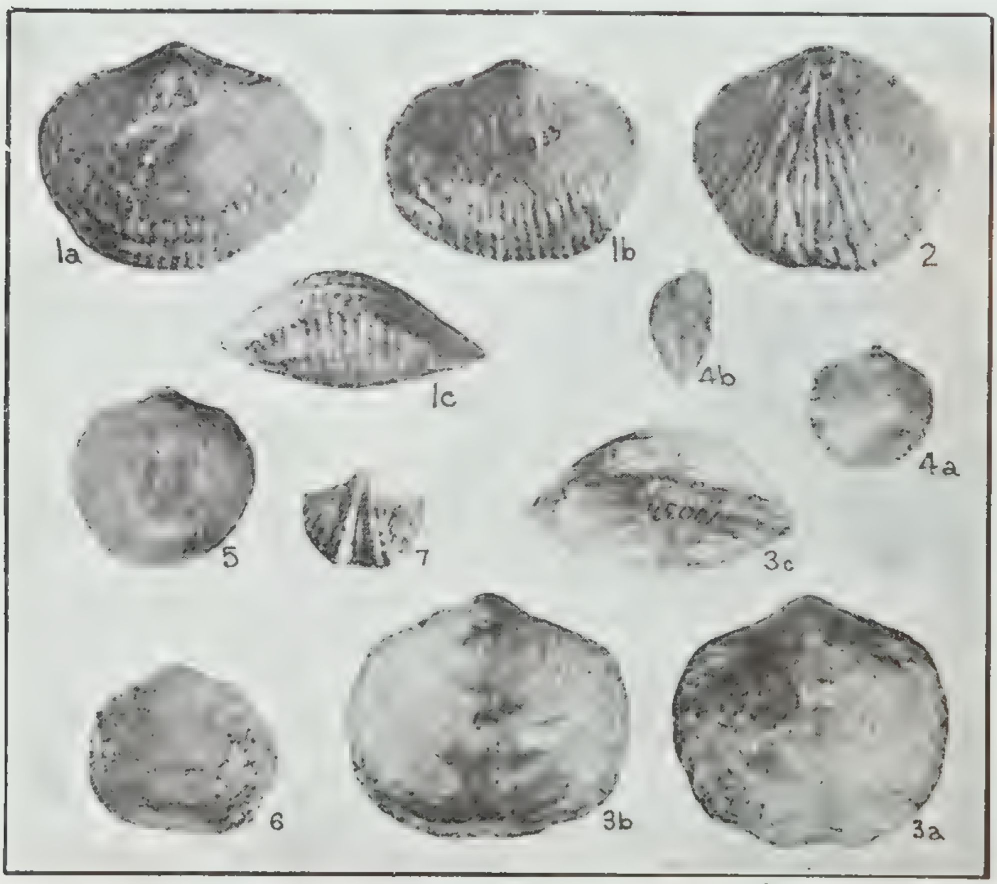
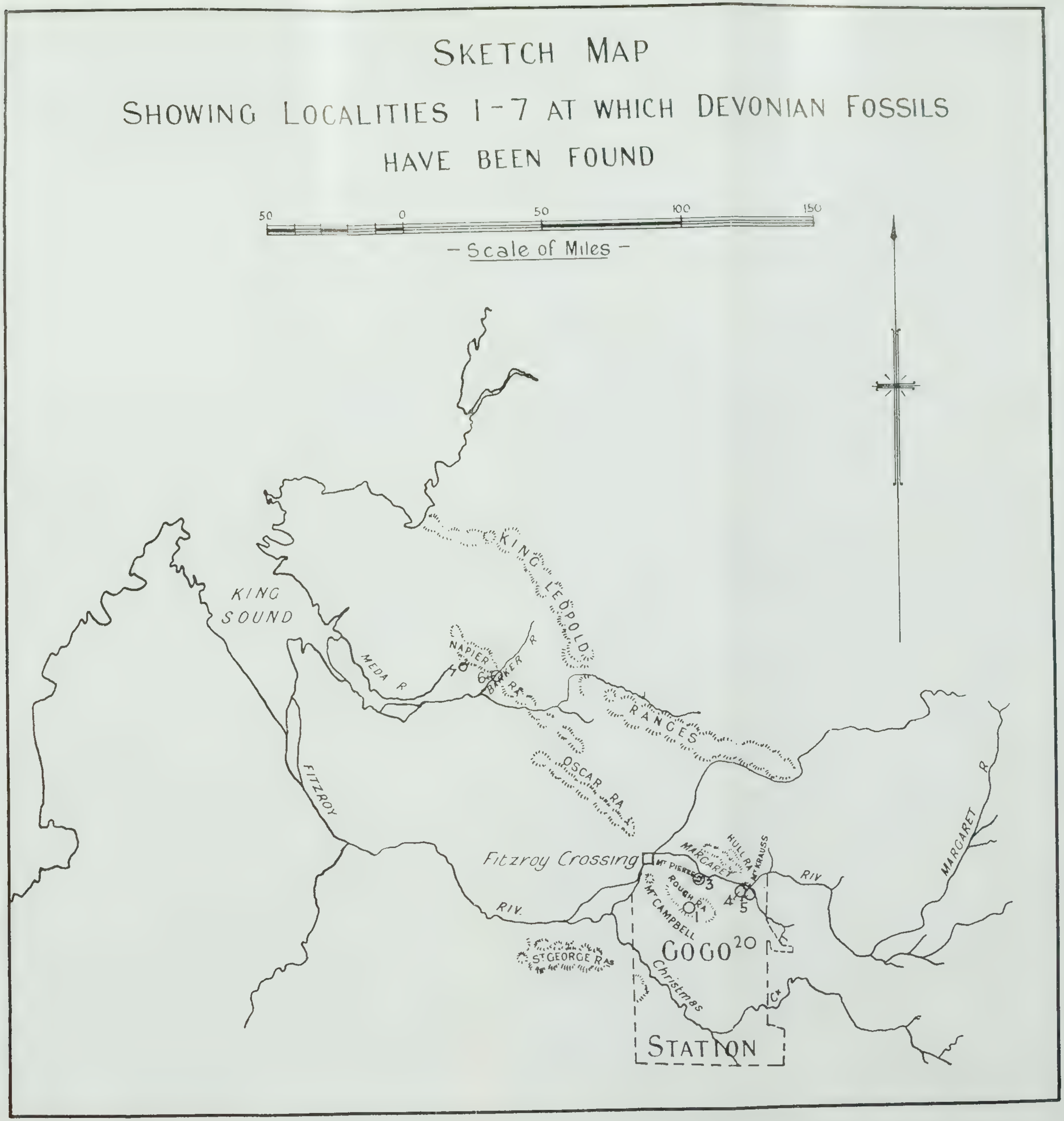


Photo. H Smith

Pl. VII.


SKETCH MAP
SHOWING LOCALITIES 1–7 AT WHICH DEVONIAN FOSSILS
HAVE BEEN FOUND
50 0 50 100 150
– Scale of Miles –
KING SOUND
MEDA R
NAPIER
BARKER R
RA
KING LEOPOLD
RANGES
OSCAR RA
FITZROY
Fitzroy Crossing
RIV.
MARGARET
HULL RA
MT KRAUSS
ROUGH RA
MT CAMPBELL
RIV
MARGARET
R
GOGO
ST GEORGE RAS
Christmas
Cr
STATION

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8.—CONTRIBUTIONES FLORAE AUSTRALIAE OCCIDENTALIS No. VIII.

By CHARLES A. GARDNER.

Read 14th March, 1933; *Published 26th July,* 1933.

INTRODUCTION.

In this paper, which contains a few species from recent collections, I have adopted the practice of describing in the English language in preference to the previous practice of describing in Latin, which is the usual procedure, excepting in those cases where a brief diagnosis is made in Latin, followed by a description in English. The reason for this is that many authors still continue to describe in English, and that a diagnosis can be made more accurate as to details when described in English, than is the case with Latin. Contribution VI. contained descriptions in both languages in order to facilitate their use amongst local botanists, and although this was not repeated in Contribution No. VII., the English explanation considered necessary to complete the diagnosis rendered the subject matter more lengthy than is compatible with the present cost of printing. It is hoped that these diagnoses will be found acceptable to botanists generally.

The Type specimens are preserved in the State Herbarium of Western Australia.

PROTEACEAE.

Diploptera, *Gardn. gen. nov.

Flowers hermaphrodite, ± regular. Perianth globose at the base, constricted upwards in a cylindrical tube, the limb globular, straight or slightly oblique, divided to the base into 4 segments which become regularly revolute in the expanded flower. Anthers all perfect, sessile in the bases of the concave laminae of the perianth-limb, the cells oblong, widely separated at the base and converging at the apices, opening in longitudinal slits; connective broad, ovate-triangular, not produced beyond the anther-cells, or very slightly so. Hypogynous scales or gland absent. Ovary on a long thick stipes, 1-celled, with one ovule pendulous from the summit on a slender and slightly flexuose funicle; style as long as the perianth-segments, rather thick, slightly curved, with a large peltate orbicular lateral stigmatic disc bearing a small linear stigma in the concave centre. Fruit a follicle, opening longitudinally along the ventral edge, liberating the seed together with two wing-like envelopes (the endocarp and mesocarp?) which closely en-

* δὶπλοος, πτεροω—double-winged, in allusion to the two wing-like envelopes which embrace the seed and its funicle.

velop the seed, together with its long funicle, and are closely appressed over the seed. The outer envelope is open along its outer margin, and free from the inner except at the extremity; the inner envelope embraces the seed from which it is entirely free, but its two surfaces are adherent above and below the seed and on the dorsal margin, being free on the ventral margin. Seed ovate-oblong in outline, compressed, suspended on a long pendulous funicle; testa coriaceous; cotyledons obovate-oblong, unequal and semi-imbricate; embryo minute.

The new genus, which belongs to the *Grevilloideae-Grevilleae,* differs from all other Australian follicular Proteaceae in the solitary ovule. It is closest related to *Roupala* and *Lambertia,* but differs from both in the absence of hypogynous scales, inflorescence and fruit, and also in the leaves as well as in the solitary ovule and seed. Drummond first collected this plant (5th Coll. suppl. No. 15) probably from the district in which it is now known to occur. Mueller appears to have first named the plant, but did not publish a description. Bentham, who examined the specimen, placed it tentatively in the genus *Hakea* as *? Hakea stenocarpoides* (F.v.M.) Benth. Bentham's reference to the two collateral ovules must refer to the comparatively large cotyledons, since I can find no trace of a second ovule, and the attachment is certainly apical. The curious structures which come away with the seed, and which I have described as "envelopes" for want of a better term, bear no similarity to those of any other Proteaceae known to me. The "plates" found between the seeds in Banksia are stated by Bentham to be the consolidated outer integuments of the inner surfaces of the two seeds. The seed of Diploptera has two complete integuments, and since the structures envelop the seed and funicle they are perhaps best regarded as parts of the fruit—the endocarp and mesocarp.

Diploptera stenocarpoides (Benth.) Gardn. n. sp. (*?Hakea stenocarpoides,* (F.v.M.) Benth.)

An erect shrub of 3-4 feet, branching from the base, the branches erect and virgate, with a few $\pm$ erect branchlets, quite glabrous, and sometimes the younger branchlets glaucous. Leaves alternate, oblong-spathulate, gradually narrowed towards the base into a petiole, obtuse and mucronate, the mucro being sometimes almost pungent, indistinctly and obliquely nerved, flat, glabrous, and a dull green in colour.

Flowers in axillary umbels, peduncles reflexed, tri-bracteate at the base, with often a smaller bract close above, the bracts small and subulate. Peduncles dilated into a small narrowly-winged expansion immediately below the insertion of the pedicels, but continuing beyond them as a short stalk with a terminal cone-shaped structure. Pedicels deflexed on the peduncles, thus bringing the flowers into an upright position, 4-8 in each umbel. Perianth glabrous, erect, the limb smaller than the globose base, the constricted portion $\pm$ straight and narrow, the segments not revolute until the flower expands; torus small, straight. Ovary on a long thick stipes which is somewhat bulbous at the base; style attaining the length of the perianth-segments, rather thick.

Fruit narrow, stipitate and fusiform, but $\pm$ compressed, opening longitudinally along the ventral margin, acute and slightly beaked at the apex, gradually narrowed towards the base, scarcely woody. Outer seed-envelope

dark-coloured, oblong-lanceolate in outline and conspicuously margined, hyaline; inner envelope pale-coloured. Seed pale-coloured with a dark base, the funicle longer than the seed and somewhat flexuose.

South-Western Australia: Warren District, James Drummond (? 5th Coll.) Suppl. n. 15.

Walpole River, H. Steedman, Febry. 1931—The Type.

Between Deep River and Shannon River, in sandy gravelly soil on rises, Gardner, Jany. 1932.

Grevillea tenuiloba, Gardn. sp. nov.

(Sect. Plagiopoda, Benth.)

A shrub of a few feet in height, the branches erect, shortly tomentose. Leaves simply pinnatisect, the segments 5-7, narrow-linear, pungently acute, convex above, doubly grooved underneath by the closely revolute margins, glabrous. Racemes many-flowered, rather dense, terminal, simple or forming small panicles, slender, the branches subtended by simple leaf-like bracts; bracteoles broad, loosely hairy and scarious, deciduous, rhachis angular or sulcate, pubescent with short silky, ± appressed hairs.

Pedicels slender, silky-pubescent. Perianth red, very sparingly pubescent outside in the lower part, the limb glabrous, glabrous inside, the tube not very broad at the base, but much attenuate and revolute under the obliquely globular limb; torus very oblique, almost vertical; hypogynous gland hippocrepiform. Ovary villous, almost sessile on the upper margin of the torus; style elongated, somewhat thick; stigmatic disc small, lateral, umbonate. Fruit not seen.

Avon district, near Dandaragan; W. E. Blackall, September, 1932.

Leaves 2-3cm. long, 1.7-2.0cm. broad, the segments 1.0-1.8cm. long, less than 1mm. broad; racemes 7-9cm. long; pedicels 4mm. long; perianth 1cm. long, the limb 2.5-3mm.; style and ovary 2.2cm. long.

The species belongs to the Sect. Plagiopoda, and is close to *G. erectiloba*, F.v.M., differing in the much smaller leaves and flowers, glabrous style, and almost sessile ovary. The perianth appears to be similar, but is shortly hairy outside in the lower portion, and perfectly glabrous within. The leaf-segments are flattened, not terete, and are rigidly divaricate.

Grevillea dryandroides, Gardn. sp. nov.

(Sect. *Conogyne*, R.Br.)

A small tufted or diffuse shrub with a rather rough, almost corky bark at the base. Leaves erect, linear-oblong in outline, simply pinnatifid, with numerous (30-40) pairs of opposite approximate segments, the segments linear, rigid, entire, glabrous, with prominent midribs, smooth and slightly convex above, the margins thick and closely revolute, doubly grooved beneath from the revolute margins, and finely silky-pubescent with crisped hairs which are only visible when the leaf is sectioned; mucronate.

the perianth, except the style, is typical of Dryandra. The foliage is quite anomalous. All the mature involucres seen were damaged by insects, and in the absence of fruits no definite position can be assigned to the species. It is probable, however, that it occurs within the Section Eudryandra, series Armatae, next to *D. armata*.

RUTACEAE.

Muiria, Gardn. gen. nov.

Calyx small; sepals 5, imbricate; petals 5, imbricate, narrow, erect, disc small; stamens 10, equal in length to the petals, slender, flattened at the base, each with a tuft of silky hairs on the inner surface above the base; anthers ovate-ellipsoidal, versatile, the connective narrow, the cells placed back to back, opening longitudinally in parallel slits, obtuse, not apiculate. Carpels 5, almost distinct from the base; styles inserted about the middle and immediately united into one, slender; stigma capitate, shortly 5-lobed; ovules 2 in each carpel, superposed. Fruit not seen.

Shrub often very small, softly hirsute with long, fine almost cobwebby hairs. Leaves simple, alternate, hairy, but becoming glabrous with age, thick and not evidently glandular; inflorescence axillary, sometimes terminal; pedicels 1-3 in the axils of the upper leaves, subtended by lanceolate bracts. Flowers yellow.

This genus is established upon the species which Mueller named *Chorilaena Hassellii.* In describing the plant (Victorian Naturalist iii. 87 (1887)) Mueller pointed out that *Nematolepis* should be united with *Chorilaena*, but should the generic separation be kept up, the new plant might as well be placed in *Nematolepis,* the differences within the genus *Correa* as regards corolla being quite as great, whereas again diversity of inflorescence would, for the extended genus *Nematolepis,* not be greater than for *Lasiopetalum.* Mueller, however, united several genera of the Rutaceae under *Eriostemon,* a practice which has not been followed by later botanists. If *Muiria* were united with *Nematolepis,* it would logically follow that *Eriostemon* should be united with *Phebalium* as was done originally by Mueller. Bentham separated the two on the aestivation of the corolla and indumentum, characters which now separate *Nematolepis* and *Muiria.* The new genus, which appears to be closer to *Nematolepis* than to *Chorilaena,* differs from the former in the free and imbricate petals, and from the latter in the simple leaves, short stamens and the inflorescence

Muiria Hassellii, (F.v.M.) Gardn. sp. nov.

(*Chorilaena Hassellii,* F.v.M. Vict. Nat. iii. 87 (1887)).

(*Muiria montana,* Gardn. Ms. in Enum. pl. Austr. occ. 70 (1931)).

A dwarf shrub, 4 to 18 inches in height; leaves small, obovate-oblong to elliptical-oblong, narrowed towards the base, almost flat, sparsely hairy as well as the branchlets, but becoming glabrous with age. Flowers in the upper axils or terminal, pendulous on short recurved pedicels; bracteoles small, linear to ovate-elliptical near the base of the pedicels; sepals small, somewhat unequal, ovate to lanceolate-elliptical, hairy outside; petals large,

Flowers in short dense secund racemes, paniculately arranged on long naked prostrate branches, the rhachis pubescent with white appressed hairs. Pedicels very short; bracteoles lanceolate, concave, ciliate, acute, very deciduous. Perianth silky-pubescent outside, glabrous inside, the tube broad and almost gibbous at the base, but narrowed above the middle, revolute under the ovoid-globular limb; torus almost straight; gland semi-lunar or almost rhomboidal; ovary villous with dense white hairs, on a stipes which is slightly longer than the ovary; style long and slender, sparsely hairy with thin white hairs, terminating in a narrow somewhat striate cone with an oblique almost bulbous base.

Avon district near Ballidu, in yellow sandy loam on low heath, usually under taller shrubs, fl. m. September, C. A. Gardner, 2711. 22nd September, 1931.

Plant rarely exceeding 20cm. in height, spreading to a diameter of 1 metre or more. Leaves mostly 12cm. long, 1.8cm. wide, the segments up to 1.2cm. in length and 1.2mm. in width. Racemes 5-7cm. long; pedicels under 2mm. Perianth 5-6mm. long, the limb 1.2mm.; style 1.5cm.

The species belongs to the Sect. *Conogyne,* R. Br., but does not appear to be closely related to any described species of this Section. The floral structure and habit of the plant are much like that of *G. thyrsoides,* except that the stigma is distinctly narrow-conical. The leaves are also somewhat like those of *G. thyrsoides,* but longer, with much more numerous, approximate and shorter segments, and are not scrabrous. Amongst the species of the *Conogyne,* it is perhaps best placed after *G. Purdieana.*

Dryandra petrophiloides, Gardn. sp. nov.

A small rigid shrub, the branches intricate, somewhat densely foliaged; glabrous except the flowers.

Leaves rigid, trichotomously divided or pinnate with dichotomous pinnae, the segments terete, rigid and pungent-pointed. Flower heads terminal on short leafy branchlets, surrounded by long floral leaves. Involucres narrow-ovoid, the outer bracts ovate-lanceolate, acute, the apex acuminate, glabrous, the margins ciliolate, the outermost bracts leafy, the peduncles scaly. Inner bracts linear, white-hairy towards and at the apex, with ± appressed hairs, and villous at the broad base.

Perianth-tube slender, plumose-villous, the limb silky-hairy and bearded at the apex with long white straight hairs; style as long as the perianth, the stigmatic end somewhat thickened and usually broadened towards the base, fusiform and minutely hirsute below the brush-like stigma. Fruit not seen in a perfect state.

Shrub 30-60cm. high, and as much in diameter, leaves 4-5cm. long and as much in breadth, twice or thrice dichotomously or trichotomously-divided, the ultimate segments 5-10mm. long. Involucres about 2cm. long; perianths about 3.2cm. long.

Near Newdegate, in sandy gravelly soil, W. E. Blackall, Nov. 1931 –The Type.

This plant has much the aspect of *Isopogon teretifolius* or *Petrophila rigida,* and might at first sight be easily mistaken for either of these species. The flowers, however, are surrounded by a narrow involucre of bracts, and

narrowly oblong-cuneate, glabrous except towards the summit, lemon-yellow with a dark median stripe, much imbricate; stamens about as long as the petals; filaments linear, provided above the base with a scale-like expansion bearing a tuft of hairs, otherwise glabrous; style elongated, capillary, glabrous; stigma small; carpels obtuse, densely hairy.

Shrub 8-35cm. high; leaves 1.2-1.5cm. long, 2-3mm. broad; pedicels about 2mm. long; bracteoles under 1mm.; sepals 3-4mm. long; petals 1.8-1.9cm. long.

On the Western side of the Stirling Range, A. Hassell.

Summit of Coyanarup, T. Muir and C. A. Gardner, 1440, 29th April, 1923.

Stirling Range near Mondurup, William Porteus, 27th June, 1930.

Summit of Isongorup, Muir and Gardner, October, 1930.

The genus is named out of compliment to Mr. Thomas Muir of Warrungup, Borden, who accompanied me on the two occasions when this plant was collected.

Asterolasia Dielsii, Gardn. sp. nov. (Sect. Urocarpus). (*A. Dielsii*, Gardn. Ms. in Enum. pl. Austr. occ. 70 (1931).

A diffuse shrub of low stature usually with trailing branches, sometimes small and erect. Leaves alternate or clustered at some of the nodes, oblong-ovate, flat, the margins slightly recurved, very shortly stellate-hairy above when young, the hairs wearing away on the older leaves, leaving scurfy scales, sparsely and coarsely stellate-hairy beneath, the midrib prominent; petioles slender.

Flowers white, on long slender pedicels in terminal and axillary umbels rarely reduced to a solitary flower, with occasionally small leafy bracts at the base. Calyx inconspicuous, the lobes triangular-ovate; petals stellate-hairy outside with rufous hairs, induplicate-valvate in the bud; stamens 20-25, the filaments slender; carpels 2, erect, united to above the middle, obtuse, stellate-hairy. Fruit not seen.

Shrub 30-45cm. high. Leaves, together with their petioles 2-3cm. long, .8-1.2cm. wide, petioles 4-6mm. long. Pedicels up to 1.2cm. long. Petals 1cm. long, 4-5mm. wide. Stamens 6mm. long. Carpels 2.5mm. long.

Hab. Darling District, by the Helena River near Glen Forrest (Smith's Mill), in loamy soil in moist shady spots, fl. m. August. 3rd August, 1924. Gardner 819A. The Type.

This apparently localised species, with affinity to *A. pallida,* differs from the latter in the larger leaves and flowers, and in the more numerous stamens. From *A. grandiflora,* to which it is also closely allied, it differs in the axillary inflorescence, absence of coloured bracts, indumentum of the corolla which is white, not pink, and in the number of carpels.

The species is named in honour of Dr. Ludwig Diels, Director of the Botanic Gardens, Berlin, who has kindly expressed an opinion on several plants submitted from time to time.

RHAMNACEAE.

Siegfriedia, Gardn. gen. nov.

Flowers hermaphrodite; calyx-tube entirely adnate to the ovary, the limb divided into 5, rarely 4 lobes, persistent and erect, valvate in the bud. Petals 0. Stamens isomerous with the calyx-lobes and alternate with them, the filaments long and erect, conspicuously exserted; anthers ovoid-oblong; disc 0. Ovary inferior, 3-celled, with 1 erect ovule in each cell; style long and slender, shortly 3-branched at the apex. Fruit (not seen in a perfectly mature condition) a capsule slightly projecting beyond the tube of the calyx, the endocarp separating into 3 crustaceous cocci opening at the base of the inner angle in longitudinal slits; seeds erect, seated on a short thickened and fleshy turbinate or sub-cupular funicle.

Shrub; branchlets and under sides of the leaves invested with a pink or rufous close stellate tomentum. Leaves opposite, petiolate, entire, coriaceous, with revolute margins; stipules very deciduous. Flowers in cymes which are abbreviated into pseudo-heads, and hidden amongst ten or twelve large involucre-like decussate bracts, of which the two outermost are smaller than the others, the four outer bracts without flowers in their axils, but usually the four intermediate with small clusters of from 2 to 4 flowers, with sometimes the addition of a few sterile flowers. There is a central or apical cluster of flowers within the bracts of from 6 to 10 flowers which are shortly pedicellate. Flower-heads nodding; bracts coloured, coriaceous and serrulate.

The new genus, which belongs to the *Rhamneae,* has its closest affinity with Pomaderris, but differs from it in the practically sessile flowers which are quite glabrous, the long erect and exserted stamens, the absence of a disc, the opposite leaves and the large persistent involucral bracts. These bracts give the plant the aspect of a bracteated Darwinia.

Siegfriedia darwinioides, Gardn. sp. nov. (*Siegfriedia darwinioides,* Gardn. Ms. in Enum. pl. Austr. occ. 76 (1931).

An erect shrub with a smooth purplish-brown bark, the branchlets canescent, the branches glabrous, erect. Leaves opposite, oblong, obtuse, the base somewhat cordate, the midrib impressed on the upper surface, the margins revolute, glabrous above and prominently reticulate, densely tomentose beneath with a bright pink tomentum which also invests the petioles of the younger leaves; stipules small and very deciduous. Inflorescence a cyme abbreviated into pseudo-heads terminating the short opposite lateral branchlets. Bracts usually 10-12 in number, all subequal, or the outermost two smaller, decussate, imbricate, orbicular, obtuse, irregularly serrulate, coriaceous, prominently nerved, red to pale pink or flesh-colour, 4-6 of the outermost being empty, the intermediate bracts often with a cluster of 3 or 4 flowers in their axils. Heads terminal within the involucre, the cluster consisting of from 6 to 10 flowers, and frequently some additional infertile flowers outside, and amongst the axillary clusters of the bracts. Caylx-tube glabrous, turbinate, 4-5-lobed, angled, the tube shorter than the lobes, the lobes valvate, ovate to ovate-lanceolate, acute, thick and coriaceous. Petals absent. Stamens exserted; filaments slender, inflected but ultimately erect; anthers versatile, 2-celled, the cells parallel; style as long as the stamens or nearly so, shortly 3-branched at the summit with 3 terminal stigmas; ovary inferior, 3-celled, ovules solitary in each cell, erect on a pulvinate funicle.

Starvation Boat Harbour, Mrs. Reynolds, August, 1925, per Mrs. Daw. The Type.

Shrub probably 60-90cm. in height. Leaves 2-3cm. long, 7-8mm. wide in the larger leaves; petioles 7-9mm. long. Bracts 1.8cm. long, 1.7cm. broad; calyx 4-4.5mm. long, the lobes 2-2.5 mm. long, 1.5mm. broad. Stamens 6-7mm. long.

I am indebted to Mrs. E. Daw of Ravensthorpe for the material of this interesting plant.

VIOLACEAE.

Hybanthus bilobus, Gardn. sp. nov. (*H. bilobus*, Gardn. Ms. in Enum. pl. Austr. occ. 84 (1931).

A small shrub with diffuse branches, the bark pale and corky, the branchlets hirsute with short spreading hairs, and sometimes terminating in short spines. Leaves scattered, usually crowded in small clusters at the nodes, widely cuneate and truncate but appearing bilobed by reason of the recurved central portion of the apex, the margins revolute, hispid with short spreading hairs. Occasionally the leaf is shortly 2-lobed.

Peduncles solitary, axillary, 1-flowered, with a pair of small ovate-lanceolate concave and apiculate bracts near the middle, minutely hairy as well as the bracts. Sepals ovate, obtuse, 3-nerved, with a minute recurved mucro, the margins fimbriolate. Lateral petals equal in length to the sepals and similar in shape but more obtuse; upper petals very slightly shorter, mucronulate; lowest petal saccate at the base, with a short broad claw and broad lamina, not twice as long as the upper petals. Filaments much shorter than the anther, subequal, the anther-appendages orange-coloured, as long as the anther-cells, the two lower filaments with short processes at the base, ± peltately attached.

Hamersley River, near the Eyre Range, in shady spots on the river banks; flowers white, blotched with pale lilac. 23rd September, 1925. Gardner 1886.

Shrub 30-60cm. high. Leaves 2-3mm. long, 2mm. wide at the apex; peduncles 3-4mm. long; sepals 2mm. long; lowest petal 4mm., including the short spur.

This species is close to *H. epacroides* (Gardn) Melchior, but the leaves are smaller and differently shaped, the sepals not hirsute, and the habit not erect, nor with divaricate, rigidly spinescent branches.

MYRTACEAE.

Eucalyptus coronata, Gardn. sp. nov. (*E. coronata,* Gardn. Ms. in Enum. pl. Austr. occ. 87 (1931).

A "Mallee" or shrub of 2-6ft. in height, stems erect, rather widely branched. Leaves alternate, distinctly petiolate, oblong-lanceolate in outline, straight or somewhat falcate, acute or subacuminate, but occasionally

obtuse, thick, lustrous, the midrib rather prominent, the secondary nerves inconspicuous, spreading, anastomosing with an irregular intramarginal nerve distant from the leaf-margin.

Peduncles axillary or lateral, much flattened and undulate, ± cuneate in outline, erect or sometimes recurved. Flowers sessile. Calyx-tube broadly turbinate, deeply corrugated; operculum conical, the base dilated and spreading, and the apex produced into a long straight beak, or the operculum shortly conical, usually wider than the calyx-tube, and like it deeply corrugated. Filaments yellow, erect in the bud, flexuose, angular and somewhat glandular; anthers oblong, opening in two longitudinal parallel slits, the connective gland dorsal. Disc prominent within the stamens, with 4 or 5 large wart-like protuberances alternating with as many smaller ones.

Fruit broadly turbinate, deeply corrugated, the rim prominent, the disc sunk below the rim but crowned in the centre by a verrucose raised boss on which are situated the slightly exserted deltoid valves, each of which has a large dorsal rounded and somewhat incurved protuberance, these alternating with smaller protuberances. Seeds large, black and angular.

Middle Mount Barren, in sandy soil among quartzite rocks on the summit, fl. m. September, 1926, Gardner 1914. Hills near East Mount Barren, H. Steedman—a form with large flowers and fruits, and an attenuated operculum. Whoogarup Range nr. Middle Mount Barren, 28th Nov. 1931. Gardner 2971.

This remarkable and handsome species belongs to the *Incrassatae*, Gardn., and has affinity to *E. goniantha*, *E. Kesselli*, and *E. megacarpa*. From *E. goniantha* it can readily be distinguished by the venation of the leaves, much larger and sessile calyx-tube, sculpture of the fruit, and apparently by the stamens also. It differs from *E. Kesselli* in the larger and differently-shaped fruit and operculum, and absence of pedicels. From *E. megacarpa* it differs in the corrugations of fruit, calyx and operculum, and from all of them in the curious warted appendages of the valves. *E. megacarpa* and *E. coronata* are the only two species of the genus which possess these peculiar incurved valves, but whereas in *E. megacarpa* it is the valves themselves which are incurved, in *E. coronata* the incurved process is really an appendage of the valve.

Eucalyptus Steedmanii, Gardn. sp. nov. (*E. Steedmanii*, Gardn. Ms. in Enum. pl. Austr. occ. 88 (1931).

A slender tree or Mallee attaining a height of 25 feet, the branches erect. Bark light brown, smooth and shining, decorticating in thin flakes, the timber dark brown. Branchlets angular.

Primary leaves narrow, but not seen in the very early stage. Leaves erect, oblong-lanceolate, usually obtuse, on short petioles, thick, lustrous, copiously oil-dotted, the midrib not prominent, the secondary nerves obscured but very oblique with the intramarginal nerve distant from the leaf margin.

Peduncles axillary, elongated, dilated and ribbon-like towards the apex, erect or rarely deflexed. Pedicels long, 4-angled, widened into the calyx-tube. Calyx-tube quadrangular-obconical, the angles produced into 4 promi-

nent wings which are gradually widened from the angular pedicel being broadest at the calyx-rim. Operculum ovoid, acute, prominently 4-angled, the angles corresponding to the 4 wings of the calyx-tube, but not continuous with the wings of the calyx-tube. Filaments usually yellow, sometimes crimson, erect in the bud. Anthers oblong, opening in longitudinal slits; floral disc none.

Fruit turbinate-obpyramidal, truncate at the apex, prominently 4-winged, gradually tapering into the angular pedicel, the capsule deeply sunk, 4-5-celled, the valves subulate and exserted.

Shrub 5-7 metres high; leaves 4-7cm. long, 4-7mm. broad; petioles 3-6mm. long. Peduncles ± 1.5cm. long, 3-4mm. broad at the apex; pedicels 1.5-1.7cm. long. Calyx 1.2cm. long (pedicel and calyx 3cm. long); calyx-tube 8-10mm. broad; operculum 1-1.2cm. long, 6-7mm. broad. Fruit (with pedicel) 3.5-3.7cm. long, 1.1-1.2cm. broad; valves exserted 4-5mm.

The species is related to *E. tetraptera* and to *E. Forrestiana,* having the same tetrapterous calyx. I have proposed a new series—*Tetrapterae*—for the reception of the three species, which differ from the other *Macrantherae* in this character of the four wings. *E. Steedmanii* differs from *E. tetraptera* in the umbellate inflorescence, the presence of well-defined pedicels, and the smaller and differently shaped leaves. *E. tetraptera* has also a differently shaped calyx-tube and operculum. From *E. Forrestiana,* to which it is more closely related, the new species differs again in the umbellate inflorescence and exserted valves. *E. Forrestiana* assumes a red colour in its buds and especially its fruits, and has a long rostrate operculum (Diels evidently described an abberant form in this respect, or the beak, which is fragile, had become detached). The valves of *E. Forrestiana* are always deeply included, and the fruit narrowed towards the apex. The leaves of the two species are somewhat similar, but those of *E. Forrestiana* are lanceolate, not oblong, and the venation is much more distinct.

Coolgardie District:—Forrestania, South of Southern Cross, H. Steedman, Febry. 1928—The Type.

Near Forrestania, L. J. H. Teakle, tree of 25 feet. Nov. 1929.

Between Forrestania and Hatter's Hill, Gardner. Oct. 1929.

Eucalyptus angulosa, Schau, var. robusta, Gardn, n. var.

A shrub of about 6 feet; leaves up to 20cm. in length, very thick; calyx-tube prominently 3-4-angled, the angles sometimes extended into narrow wings; peduncles broadly flattened, recurved; filaments red. Fruit cylindrical-campanulate, 3-4-angled, 2.5cm. long, 1.8-2cm. wide at the top; valves well included.

Kundip, near Ravensthorpe, in gravelly sandy soil. H. Steedman, October, 1930.

This variety, which might even be regarded as a distinct species, has been included under *E. angulosa* because of its resemblance to this species. It has also some of the characteristics of *E. tetraptera,* but is never 4-winged, and the fruits are differently shaped.

It differs from *E. angulosa* (the typical form) in the broader and much thicker leaves, the angled campanulate calyx-tube, and in the colour of the filaments.

Eucalyptus sepulcralis, F.v.M. var. robusta, Gardn, n. var.

An erect bushy shrub of 8 to 10 feet in height with rigid angular branches, and rather broad erect leaves. Peduncles angular, slender, erect or spreading; fruits urceolate-globular, erect. Flowers with yellow filaments.

Mount Bland; H. Steedman, November, 1932.

This variety differs from the typical species in its Mallee form and erect rigid habit, otherwise it is much like the species, except that it is not pruinose on the buds, and the fruit is more robust, and scarcely contracted at the orifice. Both the buds and fruits are also larger.

Baeckea Baileyana, Gardn. sp. nov.

An erect shrub, probably tall, glabrous, with slender erect virgate branches and branchlets. Leaves opposite, appressed to the branchlets, linear-triquetrous, shortly but distinctly petiolate, glandular and somewhat keeled, the apex mucronately uncinate, the uppermost leaves shorter than the others. Peduncles erect, usually longer than the leaves, bearing usually 7 flowers on erect pedicels. Bracts lanceolate-acuminate, concave, deciduous. Bracteoles situated at the bases of the pedicels, lanceolate to oblanceolate or almost linear, acute, deciduous. Pedicels slender; calyx-tube widely turbinate, shortly 5-angled, the lobes ovate-orbicular with hyaline margins, each produced into a long horn-like point from near the centre of each lobe, proceeding distinctly from below the apex of the lobe, and exceeding it in length. Petals white, orbicular in outline, entire, almost twice as long as the calyx-lobe appendages. Stamens 10, short, regularly arranged; filaments slender, inflected, very deciduous, the cells deeply furrowed and opening in the furrows; connective not prominent. Ovary 2-celled, concave at the summit, with about 8 ovules in each cell on a peltate placenta. Style exceedingly short.

Shrub probably 2 metres in height. Leaves 5-8mm. long; peduncles 5-10mm. long; pedicels 2-4mm. Bracts 1.5-2mm. long; bracteoles 1.5mm. long. Calyx-lobes 1.5mm. long, the appendages 1.5-2mm. long; petals 3-4mm. diameter.

Habitat in the Avon district near Bruce Rock, in gravelly soils forming thickets. Eric T. Bailey, Oct. 1932. The Type.

The new species belongs to the Subgenus *Hysterobaeckea,* Niedenzu, Section *Oxymyrrhinae,* and has affinity to *B. Elderiana,* from which it differs in the appressed leaves which are only shortly uncinate, the 7-flowered inflorescences, the 2-celled ovary and the calyx-lobes, which are somewhat like those of *B. Elderiana,* except that the appendages which are much like what Pritzel terms the "lobes" of that species, are almost acicular, the lobed margins of the tube being developed as sepal-like organs with these processes distinctly dorsal.

Verticordia Mitchelliana, Gardn. sp. nov.

A shrub of 2-3ft., apparently erectly branched. Leaves linear, subterete, mucronate, crowded towards the apices of the branchlets. Flowers rather large, intense scarlet, solitary in the upper axils, forming dense leafy clusters towards the ends of the branches; pedicels slender. Calyx-tube with a ring of very short hairs at the base, otherwise glabrous, 5-ribbed,

cylindrical and narrow at the base, then abruptly widened in the free part and hemispherical, almost 5-lobed; primary lobes 5, deeply and irregularly divided into numerous cilia, and 5 accessory outer lobes similarly divided, reflexed on the tube and turned up from its base; petals ovate-oblong, subacute, lacerated irregularly at the apex, shortly adnate to the staminal tube. Stamens united in a short tube; filaments smooth, flattened and incurved; anthers ovoid-globular, opening in 2 small pores; staminodia almost twice as long, linear, acuminate, with a narrow-triangular base. Style straight, elongated and slender, bearded for some distance below the capitate stigma with rather long glandular hairs.

Shrub, less than a metre high; leaves 7-10mm. long; pedicels 6-8mm; flowers 1cm. in diameter; petals 5mm. long; filaments 2.5mm.; staminodia 4mm. long; style 2-3cm. long.

This species has affinity with *V. monadelpha* and *V. Pritzelii.* From the former it can be distinguished by the shape and size of the petals, the staminodia and style, and from *V. Pritzelii* by the shape of the petals which are lacerated-ciliate with long cilia, the eglandular staminodia, and exceptionally long style which is bearded all round for some distance.

Avon district, near Bencubbin, October, 1929, James Mitchell—The Type. Uberin Hill, Dowerin, C. A. Fauntleroy.

This handsome species is named in honour of Sir James Mitchell, K.C.M.G., late Premier of Western Australia, who collected this plant, and whose efforts in advancing settlement in the eastern areas have rendered possible a more detailed knowledge of the vegetation of a hitherto botanically little known region.

MYOPORACEAE.

Eremophila Muelleriana, Gardn. sp. nov. (*E. Muelleriana,* Gardn. MS. in Enum. pl. Austr. occ. 119 (1931)).

A shrub of 3-4 feet, with the habit of *E. eriocalyx,* the branches slender and marked with the cicatrices of fallen leaves, but the periodicity not well marked, the branchlets minutely hoary-tomentose. Leaves not dense, alternate, petiolate, obovate, flat, closely and densely tomentose with sulphur-coloured stellate hairs, very obtuse and rather thick but soft.

Flowers solitary in the axils of the upper leaves; pedicels straight, slender, loosely tomentose with long branched white hairs which invest the calyx also. Calyx divided to the base, the segments oblong-linear, obtuse, tomentose on both surfaces with loose-branched white hairs. Corolla almost campanulate with a short cylindrical base, then much dilated, the lobes short and broad, almost equal, the anterior lobe broader than the others and deeply lobed; throat bearded inside with long loose hairs, externally pubescent with short hairs. Stamens included in the tube, or scarcely exserted, $\pm$ equal in length; anther-cells divergent, confluent at the summit. Ovary conical, glabrous, tapering into the style, the style slender, with a few spreading short simple hairs.

Leaves 1.3-1.5cm. long, 6-8mm. wide; petioles 2mm. long; pedicels $\pm$ 1cm. long; calyx-lobes 1.3-1.4cm. long; corolla 2.5-2.7cm. long, lobes 8mm. long by 7mm. broad, the anterior much broader; ovary and style 2.5cm. long; stamens $\pm$ 1.7cm. long.

Austin district, Roderick River near Kalli Station, west of Cue, G. Buchanan, September, 1927—The Type.

The species belongs to the Sect. *Eriocalyx,* and has affinity to both *E. compacta* and *E. eriocalyx.* It differs from *E. compacta* in the distinctly petiolate leaves which are much wider and not pustulate, the longer pedicels and curious loose vestiture of branched hairs, also the pubescent corolla. From *E. eriocalyx,* to which perhaps it is most closely allied, it differs in the smaller and differently shaped leaves and differently shaped corolla. The vestiture of the flowers is, however, like that of *E. eriocalyx,* and the calyx is of the same shape.

I have named this handsome plant, one of the most showy of the genus, conspicuous by reason of its deep red-violet flowers and yellow leaves, after Baron Ferdinand von Mueller, who did much to elucidate the species of this large genus in which he also commemorated the names of so many prominent Australian explorers during the early days of settlement, and who is also entitled to be numbered amongst them.

GOODENIACEAE.

Antherostylis,* Gardn. gen. nov.

Calyx divided to the base, free or adnate to the ovary at the base only, the sepals or segments 5, unequal, the anterior one longer than the others, and outermost in aestivation, the 4 lower segments ± equal. Corolla oblique, the tube shortly adnate to the ovary at the base, gibbous on the lower side and produced into a hollow spur between the two lowest calyx-segments, split on the upper side almost to the base and deeply divided into 5 lobes, the two upper lobes not more deeply separated than the three lower, all equally winged, the three lower lobes oblong, straight, the two upper falcate and inflected over the tube. Anthers free. Ovary almost entirely free, shortly adnate to the corolla, imperfectly 2-celled, the dissepiment not extending beyond the middle; ovules indefinite, ascending. Style simple; indusium vertical, not cupular, appearing in the bud as four lateral vertical wings connected at the base and extending along each side of the style and continuous over the summit, free except at the base and forming two vertical hippocrepiform membranes which become laterally involute as the flower opens, resembling the two cells of a vertical adnate anther. Style a wide membrane extending throughout the entire length of the indusium between the two folds, continuous, and exserted (and apparently stigmatic also) only at the apex. Capsule superior, 2-valved, imperfectly 2-celled; seeds flat annular-winged.

Herb with the habit of *Goodenia pinnatifida;* leaves radical, toothed; stems bracteate; bracts opposite, foliaceous, peduncles long, erect; flowers yellow, solitary.

The genus has the general appearance of a *Goodenia,* with the floral structure of *Velleia* in which it might be included but for the remarkable indusium which is quite unlike anything known to me within the family. *Velleia* and *Goodenia* have both a distinctly cupular indusium, while the in-

* *ανθηρος - στυλος*—relating to the anther-like form of the style.

dusium of *Antherostylis* in appearance suggests a large central anther within the flower. This indusium is very wide and extends down the opposite sides of the style for some distance as two opposite and parallel wings which are continuous and free except at the base. This is well shown in the bud, but as the flower expands these lateral "wings" become involute, the outer lip or wing, being the larger, conceals the inner lip, imparting to the whole indusium the appearance of two longitudinal cells which are confluent at the apex. The stigma develops later as a continuous membrane traversing both "cells" in which it is enclosed, being shortly exserted only at the summit.

Leschenaultia has a bilabiate indusium, but this is semi-cupular and horizontal, not vertical.

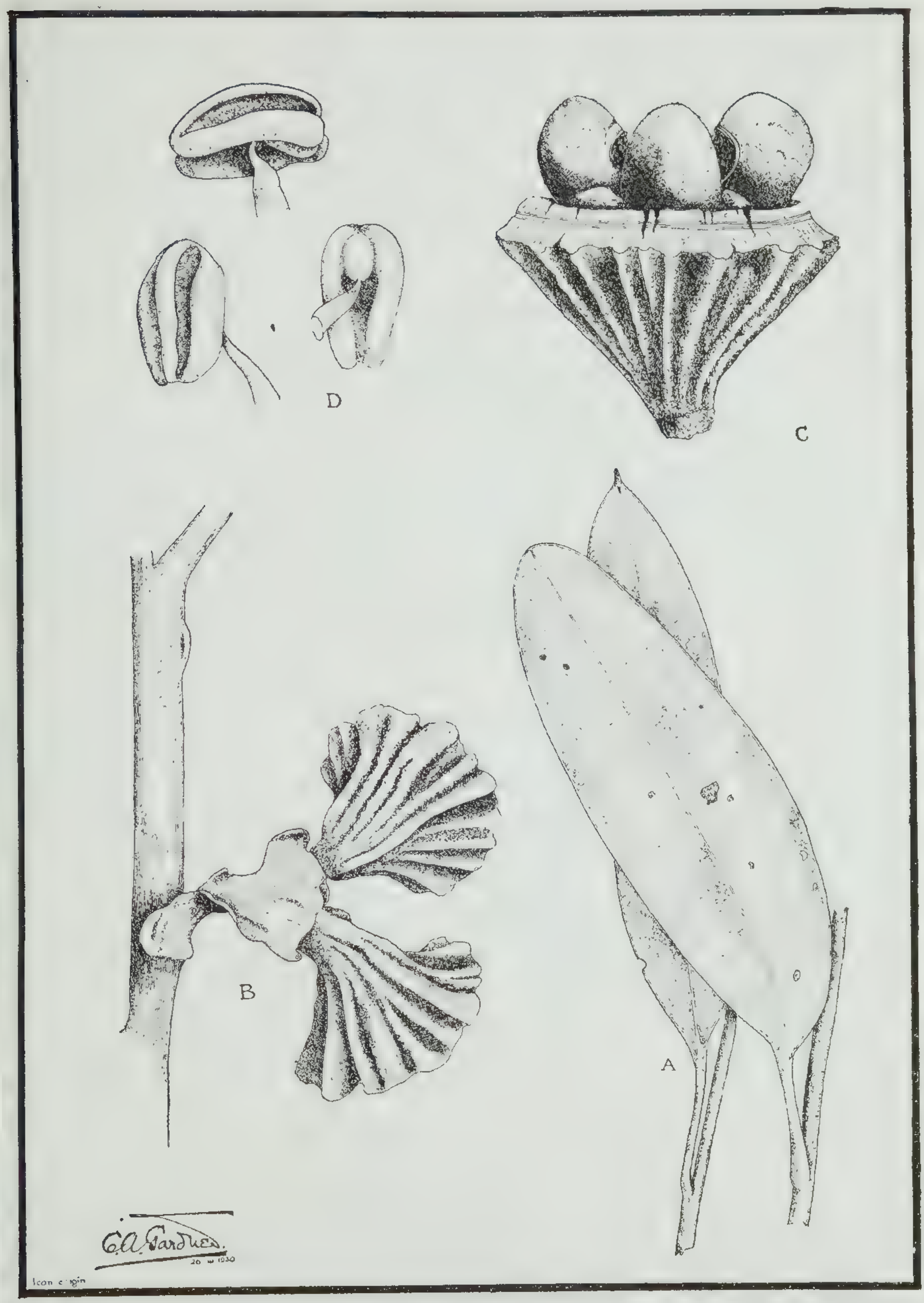
A. calcarata, Gardn. sp. nov.

Herb, apparently perennial, with tufted radical leaves and decumbent or ascending, rarely erect, stems. Leaves obovate-spathulate, mostly deeply toothed, or sometimes crenate, attenuated towards the base into a long petiole, glabrous except at the margins which are ciliate with fine short hairs, thick and ± glaucous. Stems (scapes) slender, ascending or erect in the smaller plants, glabrous and striate, simple or trichotomous with opposite leaf-like bracts (stem-leaves) subtending the lateral branches. Bracts mostly lanceolate to oblong or obovate, with 1 or 2 linear lobes near the base, crenate or dentate in the upper part, ciliate. Pedicels long and slender. Bracteoles in pairs about the middle of the pedicel, shaped like the bracts and usually 2-toothed, ciliate with a few hairs. Calyx of free segments or sepals, the uppermost larger than the others, ovate-oblong, subacute, often crenate or slightly dentate, broad at the base and almost cordate, the margins somewhat recurved at the base, outermost in aestivation; lower sepals ± equal, shorter than the upper and narrower, all ciliate with short hairs. Corolla yellow, the tube gibbous at the base, produced into a prominent hollow spur between the two lowest lobes; segments equally divided; the three lower oblong, straight, acute; the two upper falcate and inflected, all trinerved and equally winged, pubescent without, glabrous within; filaments flattened. Ovary ovoid, almost entirely superior, shortly pilose, style thick and straight, with short spreading hairs, adnate for nearly half its length to the indusium; indusium oblong in outline, pilose on the back of the subcoriaceous outer lip; the inner lip membranous and glabrous or almost so. Capsule ovoid, shortly and densely pilose; seeds densely packed, dark with a white hyaline circular wing.

Plant 10-20cm. high, spreading to 30cm. Leaves mostly 5-6cm. long up to 1cm. wide; pedicels 9-14cm. long; bracts 1-2cm. long; bracteoles 3-5mm. long. Upper sepal 1cm. long; lower 8mm. Corolla 2.0-2.2cm. long; indusium 6mm. long by 2mm. wide; capsule 8mm. long.

Hab. in Distr. Eyre, at Junanna Rocks, 15 miles N.W. of Mount Ragged, Russell Range, in grey kaolitic calcareous soil, in woodlands of *Eucalyptus occidentalis* and *Callitris verrucosa*, fl. m. Oct. 1931. Gardner 2909—The Type.

I collected this interesting plant in company with Dr. W. E. Blackall during an excursion to Israelite Bay in 1931.



EUCALYPTUS coronata, Gardn. MIDDLE MT. BARREN: 23 Sept., 1926.

THE TYPE: Gardn. 1914. A—Leaves, showing oblong form, obtuse and mucronate. B—Inflorescence, the stamens recently fallen. C—Fruit. D—Anthers.

Pl. VIII.

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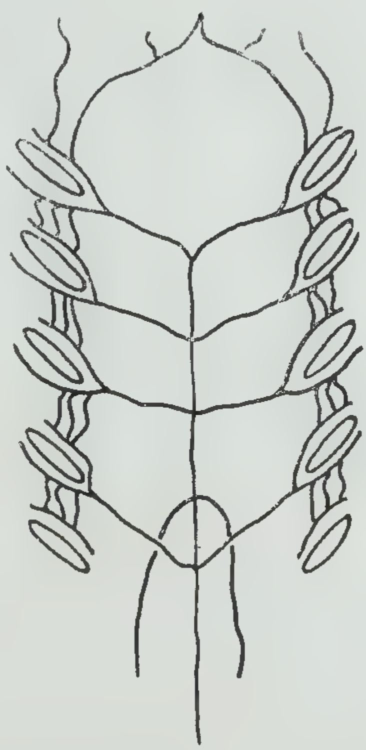
9.—NOTE ON ABNORMAL BRANCHIAL ARTERIES IN ACANTHIAS VULGARIS.

By G. Bourne.*

Presented 26th June, 1933; Published 26th July, 1933.

Out of seventy specimens of *Acanthias vulgaris* sent to the University of Western Australia from the Millport Marine Biological Station, Buteshire, Scotland, one exhibited an aberration of the arrangement of the efferent branchial arteries which is described hereunder.



Text Figure 1.

Arrangement of the normal branchial arteries in *Acanthias vulgaris*.

(Number of epibranchials and disposition of vessels represented diagramatically.)

As shown in Text Fig. 1, the dorsal aorta normally gives off two branches which proceed to the fourth gill cleft around which they branch, forming collector loops. The fifth gill cleft possesses only an anterior collector vessel, there being no posterior hemibranch. A number of anastomoses connect this branch with the posterior branch of the fourth efferent branchial.

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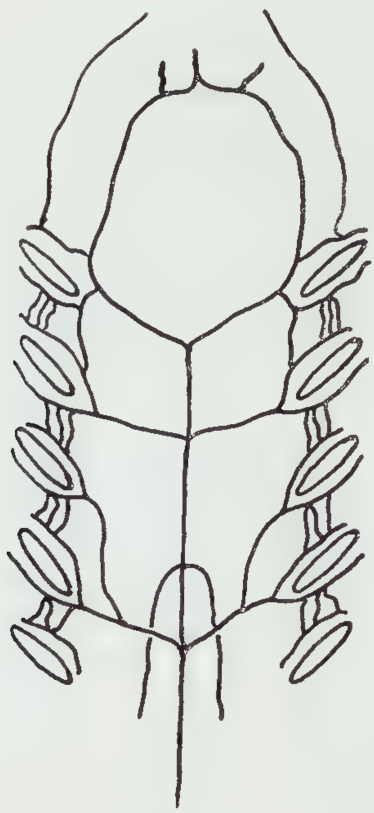
The next vessels to be given off from the dorsal aorta are the two subclavians which run backwards.

Then the third efferent branchials supply the third cleft, and the second and first efferent branchials the second and first clefts respectively. The collector vessel of each hemibranch is connected with the collector vessel of each adjacent hemibranch by a number of anastomoses.

From the collecting vessel of the anterior hemibranch of the first cleft are given off, from either side, an hyoidean epibranchial artery, and an efferent spiracular artery.

These are the main features of the normal efferent system in *Acanthias vulgaris.*



Text Figure 2.

Arrangement of abnormal efferent branchial arteries in *Acanthias vulgaris.* (Diagramatic. (See Text Figure 1.))

As shown in Text Fig. 2, the dorsal aorta gives off, as in the normal arrangement, efferent branchials on either side, which proceed to the third gill clefts. In addition, these efferent branchials give off on each side a large vessel, which proceeds to the fourth cleft, and these arteries are thus really the third and fourth branchial arteries combined. The posterior and anterior collecting vessels of the third and fourth clefts respectively are joined, as in the normal arrangement, by a series of anastomoses.

The subclavian arteries are next given off in a normal fashion.

The second efferent branchial divides around the second branchial cleft, and the anterior collecting vessel gives off a large branch which connects with the first efferent branchial, giving off, *en route,* a posterior collecting vessel to the first gill cleft.

DISCUSSION.

It is difficult to assess the significance of this aberration: it may have some phylogenetic significance, or again it may be solely a malformation, hereditary or acquired.

The common origin of the third and fourth branchial arteries may have been formed by fusion of these two arteries at one point, the two root portions persisting until the anterior or the posterior disappeared, leaving a common root for the two vessels.

In the anterior region, the posterior collecting vessel of the first cleft appears to have branched into two equal divisions—one proceeding to the posterior region of the first cleft and the second connecting with the anterior collecting vessel of the second cleft close to its point of origin with the posterior collecting vessel of this cleft. The anterior collecting vessel of the first cleft appears only as a secondary outgrowth from the large hyoidean epibranchial artery.

The tendency of the fourth vessel to disappear may be of phylogenetic importance, for in the course of evolution it is the *fourth branchial arch which disappears in those forms which develop lungs. Even in the tadpole during metamorphoses the fourth vessels lose their connections with the atrophying branchial clefts, and in the fully developed frog do not appear to be present.

Despite this tendency of the third arch to disappear, no other important modifications appear to have taken place. There is no trace of a branch of the †fifth arch to any structure resembling a swim bladder.

Presumably this aberration is in the nature of a mutant of the series which resulted in the final emancipation of vertebrates from an aqueous environment. The series which one would expect would be rather in the nature of, firstly (as occurs in Dipnoans), a branch of the fifth branchial arch to the swim bladder, followed then by increased vascularisation of the swim bladder, and subsequent atrophy of the gills with concomitant changes in the vascular system supplying them. The development of carotids, systemic and pulmonary arches and the disappearance of the fourth branchial arch following on these changes.

This modification has appeared at a stage in which none of the preceding developments have taken place, and is therefore simply an independent mutation of interest from a phylogenetic point of view.

* Embryologically fifth branchial arch. † Embryologically sixth branchial arch.

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GENERAL INDEX.

GENERAL INDEX—*continued.*

GENERAL INDEX—*continued.*

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